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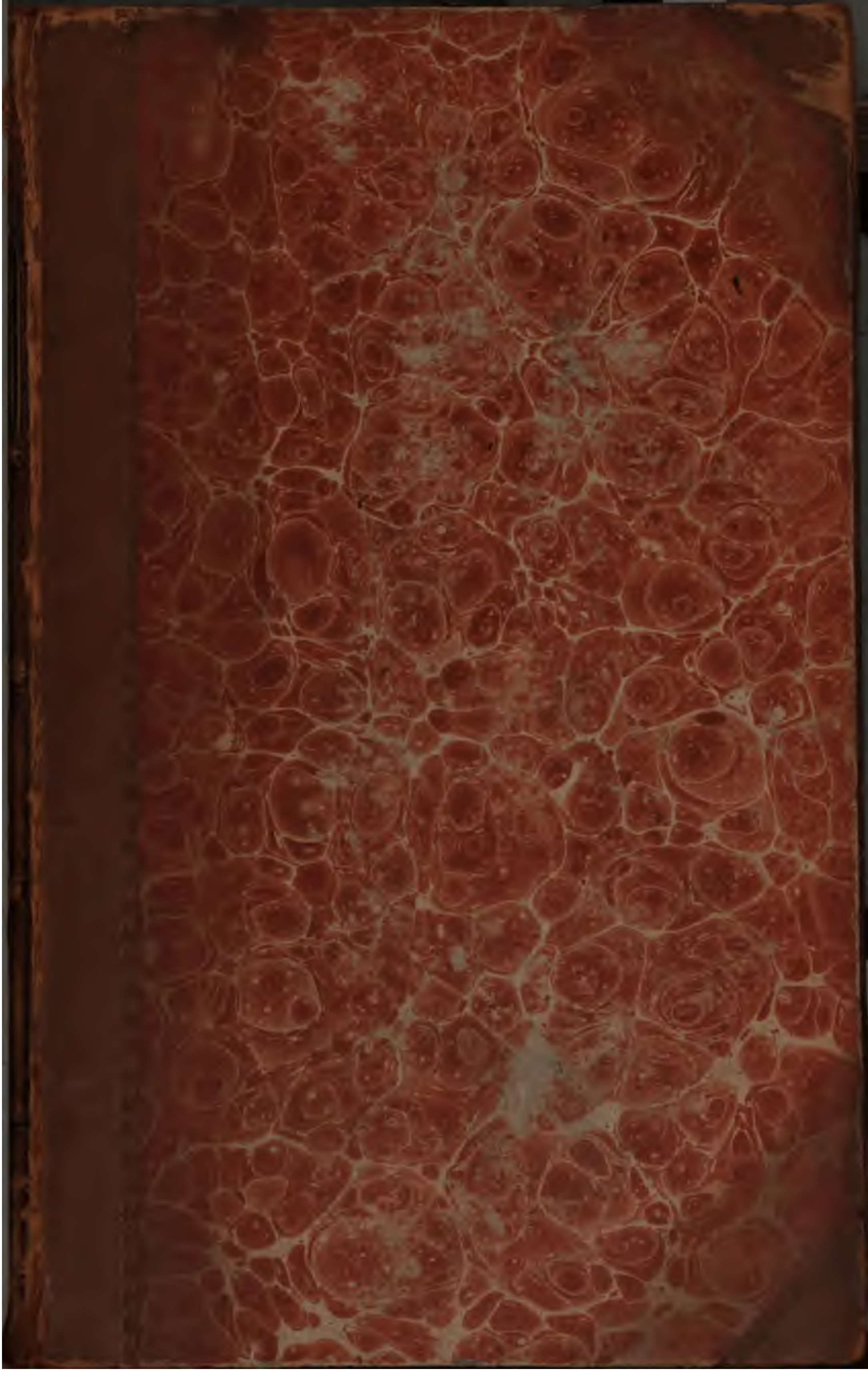

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ELEMENTS
OF
THE HISTORY OF PHILOSOPHY
AND SCIENCE.

ELEMENTS

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ELEMENTS

OF

THE HISTORY

OF

PHILOSOPHY AND SCIENCE,

FROM THE

Earliest Authentic Records

TO

THE COMMENCEMENT OF THE EIGHTEENTH CENTURY.

BY THOMAS MORELL,

AUTHOR OF "STUDIES IN HISTORY," &c. &c.

BIBLIOTHECA BODLEIANA

LONDON:
PRINTED FOR B. J. HOLDSWORTH,
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1827.

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PREFACE.

The principal contents of this elementary volume were first collected solely with a view to private academical instruction, and intended to be accompanied with additional oral information. This circumstance is stated to account for the technical and didactic form in which they appear. Had it been the primary design of the Author to submit his work to the public eye, he would probably have adopted a less scholastic arrangement of his subjects, and indulged in greater freedom of composition; but the information would, in that case, have been less condensed, the method less perspicuous, and the volume itself, though more generally attractive, of less intrinsic value.

There are several classes of persons to whom the Author ventures to hope the present Work may prove acceptable and useful. It may revive, in the minds of those who have formerly passed through a course of scientific education, some agreeable recollections of pursuits and objects, which have almost faded from their remembrance. It may serve, in some degree, to guide the inquiries and stimulate the exertions of those, who, having completed the elementary process of classical literature, are just entering upon the higher departments of philosophy and science. Nor will it be wholly uninteresting, it is presumed, to others, who, placed in circumstances less favourable to the acquisition of knowledge, yet eager in its pursuit, are desirous of finding, within a narrow compass, and ready collected to their hands, a mass of information on scientific subjects, which they have neither leisure nor opportunity to collect for themselves. The Author will be happy, if the labour bestowed on the compilation of the following pages shall contribute, in any degree, to supply the wants, or gratify the wishes, of these several classes of intellectual inquirers.

It is the business of the historian faithfully to record, not to invent. All, therefore, that can reasonably be expected of him is, that he look well to the accuracy of his statements, and the credibility of his authorities. Under this conviction, the Writer of the present Volume felt himself at full liberty to gather, from any authentic source to which he had access, whatever was suited to his purpose, whether found among the records of antiquity, or in the works of modern authors of acknowledged reputation. In a performance of this description, which is avowedly a compilation, making no pretensions to *originality*, but solely to *fidelity* of narration, the Author presumes he will not be chargeable with an improper use of the literary labours of others, if he have, in many instances, preferred to adopt the words of the respective authors themselves, instead of investing their recorded facts with his own phraseology.

It was at first the intention of the Writer, to have appended to each lesser division of his work, a complete list of authorities, both ancient and modern; but, on reflection, it appeared to him, that these numerous references, besides occupying a considerable space, would rather look like a parade of extensive reading, than answer any valuable purpose. He determined, therefore, to confine his references either to direct quotations, or to those specific cases in which ampler information might be desired than could be given in these elementary pages.

It will be seen, that the Author closes his retrospect with the commencement of the eighteenth century. His principal reasons for doing so are, that the age of Locke and Newton constitutes a most remarkable æra in the history of the human mind, since these illustrious individuals may justly be accounted *founders of new schools in physical and intellectual science;* that, subsequently to that period, the ramifications of human knowledge have become so numerous, as to require a series of volumes for even the most cursory review; and, especially, because a variety of small elementary works already exist, in which the later improvements of science are accurately and minutely described.

The Writer of this Volume is not so presumptuous as to imagine, that the eye of criticism will not detect some inaccuracies or omissions, into which he may have inadvertently fallen, while taking so wide a range, and touching upon so great a variety of subjects. He knows not whether it will be admitted as an apology for such imperfections in his Work, that it was written amidst the pressure of numerous important avocations; and that he could only devote to its compilation, fragments of time, snatched with difficulty from his official duties. Should such inaccuracies or omissions be found, when his volume shall have been submitted to the test of enlightened criticism, the Writer will most thankfully receive such suggestions, from whatever quarter they may proceed; and, if a future opportunity present itself, will practically express his obligations, by endeavouring to correct the former or to supply the latter.

WYMONDLEY COLLEGE,
May 25, 1827.

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ELEMENTS

OF THE

HISTORY OF PHILOSOPHY AND SCIENCE.

INTRODUCTION.

SECTION I.

PRELIMINARY AND EXPLANATORY REMARKS.

1. THE department of History, which the present work is intended to embrace, is most extensive, and perpetually increasing in interest and in importance. To trace back knowledge to its source—to mark (if it be possible) the precise points, from which all the innumerable rays of science have diverged, by which the world has been illumined, and the directions they have severally taken—to observe the progress of the human mind through all its successive stages of improvement, from the first and feeblest efforts of human genius, to its boldest flights and loftiest elevation—to survey attentively the æras which have been most memorable, and the individuals who have been most celebrated in the annals of philosophy and science;—these are objects

which cannot fail to interest the intellectual enquirer, far more than the afflicting details of human vice and misery, with which the pages of general history have too commonly been filled. Especially is it desirable in a day like the present, in which new and important discoveries are continually making in almost every department of general knowledge, that the earliest indications should be observed of those intellectual advances, which have contributed, in no ordinary degree, to the improvement of society, and the happiness of mankind.

2. Many are the gradations through which the mind of man must necessarily pass, in advancing from that state of barbarism and ignorance, in which the great mass of the population of our globe once was, to that high degree of civilization and refinement, which many amongst them have subsequently attained. In some cases the process was slow and almost imperceptible; in others, it has been rapid and brilliant, so that its course may be distinctly traced. The stream of knowledge has, at some periods, gently flowed from land to land, becoming wider and deeper as its course extended; at others, it burst forth, like an impetuous torrent, with mighty and resistless energy, surmounting every obstacle, and bearing down all opposition. In almost every instance, however, it will be found that the origin of the arts and sciences is veiled in impenetrable obscurity; nor is it till considerable advances had been made in them, or some distinguished individual arose, who gave celebrity, by his genius and talents, to the science in which he excelled,

that the historian is able even to ascertain their existence: and subsequently to the period of their commencement, in endeavouring to describe their progress, it is amidst much uncertainty and many fabulous traditions, that he can make his way to the clear day-light of historic truth.

3. The terms PHILOSOPHY and SCIENCE, have sometimes been confounded, though they have obviously an appropriate and definite signification. It may not indeed be necessary that the distinction between them should, on all occasions, be distinctly marked; nor will it perhaps be found that, in the following pages, that distinction has been uniformly preserved with logical accuracy; but at the commencement of a work professedly designed to give an outline of the history both of philosophy and science, it is manifestly proper that their precise import should be explained, and their respective boundaries defined. The term *Philosophy* was primarily used to denote the pursuit of Wisdom, and applied indiscriminately to every object of human knowledge. It comprehended all the subjects of investigation, about which the powers of the human understanding can be employed,—whether physical, intellectual, or moral,—whether speculative, theoretical, or practical. Originally all men of learning, however slender their attainments might be, were dignified with the appellation of *σοφοι*, or *Wise Men.* But in process of time this truly honourable title fell into discredit, having been assumed by mere pretenders to knowledge and erudition; so that the name, which was at first an enviable distinction, became a term

of obloquy and an occasion of reproach. This led the more intelligent and modest among the ancient men of letters to appropriate to themselves the appellation of *Philosophers,* as indicating that they were rather to be accounted the admirers of wisdom, and persons ardently engaged in its pursuit, than in actual possession of this invaluable treasure. But many years had not elapsed, ere this title also became as perverted and degraded, as that which had preceded it, insomuch that every inventor of a new theory, however absurd and frivolous, assumed to himself the name of a Philosopher. The abuse of a term is, however, no just argument against its proper and legitimate use. If the definitions of the illustrious Bacon be correct, who terms it, in one part of his admirable writings, "*Scientia rerum cum causis,*" and in another place, "*Interpretatio naturæ;*" if its primary object be the discovery and development of truth, and if its influence and tendency be to improve the condition and augment the happiness of man, by increasing his knowledge of God, of himself, and of the world which he inhabits,—it may well deserve the ardent and unwearied pursuit of every intelligent mind.

4. SCIENCE, as its very etymology would indicate, bears nearly the same relation to knowledge, which Philosophy bears to Wisdom. It has to do with facts rather than principles; with practice, rather than abstract reasonings and speculations. While Philosophy is employed in the contemplation of physical or moral truths, for the purpose of developing and explaining their hidden causes, their essential

or accidental properties, their mutual relations and modes of existence, it is the province of Science, properly so called, to bring these principles to bear on the convenience and comfort of mankind, to prove their utility, and to suggest methods of improvement. Thus, while Philosophy investigates the grounds of human judgment, or the fundamental laws of human belief, the Science of Logic shews how they may be best applied to the purposes of correct reasoning, and the elucidation or demonstration of truth. If this representation be correct, it will be evident, that while Philosophy and Science have their distinct provinces, they are, at the same time, necessarily and intimately connected,—that every genuine philosopher will be, to a certain extent, a man of science,—and that whoever excels in any department of science, contributes essentially to the advancement of philosophical knowledge.

5. It will, of course, be impossible that a professedly elementary work, taking so wide a range as the present, should include all, or even a thousandth part of that immense mass of information, which might, with the utmost propriety, be introduced into a History of Philosophy and Science. Such a work might not improperly comprehend a survey of all the doctrines and opinions of men, in all ages and countries, on philosophical and scientific subjects,—a review of the systems which have been devised and propagated,—and a development of all the discoveries which have been made in every department of physical and moral science, or in the useful and ornamental arts, together with their

progressive stages of improvement. It is hoped, however, that the youthful reader of these pages (for whose benefit and instruction they are chiefly designed) will bear in mind, and others need not to be admonished, that these volumes are but intended to exhibit the *elements* of these comprehensive subjects; and that it can be but a cursory glance which is taken of so vast an extent of scenery, interesting as every object it contains must necessarily be to the mind ardently engaged in the pursuit of knowledge. To compensate in some measure for this deficiency, the reader will be referred continually to other works, both ancient and modern, from which ample information may be obtained.

SECTION II.

GENERAL CLASSIFICATION OF THE OBJECTS OF HUMAN KNOWLEDGE.

6. THE title prefixed to this section may seem presumptuous, especially to those who may have read, with attention, the elaborate essay of Dugald Stewart on the subject, prefixed to his valuable "Dissertation on the Progress of Mental Philosophy since the Revival of Letters;" in which that distinguished writer, after having investigated the proposed arrangements of the various departments

of knowledge suggested by men of pre-eminent genius both in ancient and modern times, attempts to prove the insurmountable difficulty of the undertaking, at least in the present state of human science. Presumptuous indeed must that individual be, who should promise to himself the execution of a task, which a writer, who unquestionably ranks highest among the intellectual philosophers of the age, has abandoned as hopeless. No such design, however, is meditated by the present writer. All that he purposes is, to exhibit in one view the principal attempts which have been made towards the classification of the objects of human investigation, without presuming to determine their philosophical accuracy, and still less to decide on their comparative merits. The importance of such a general survey, which (to adopt the language of a celebrated French writer) "should comprehend in one general scheme, all the various departments of study, arrange them into proper classes, and point out their mutual relations and dependencies," all must acknowledge; while the difficulty of effecting it with logical precision, will be sufficiently evident from the brief notices about to be exhibited of the imperfect and unsuccessful attempts hitherto made.

7. The most ancient philosophers of Greece divided the objects of human knowledge into three classes;---*Dialectics*, which direct the operations of the mind, and teach the right application of its powers:—*Physics*, including under that term not only the structure of the universe and the phenomena of nature, but also the existence and attributes

of God, and the nature of the human soul;—and *Ethics*, which treat of the personal and relative duties of moral and intelligent agents. But in process of time, the impropriety was felt of classing those departments of knowledge, which were purely intellectual, with those that related to material substances and the objects of sense; and hence arose a further division, by which the properties and operations of mind were distinguished from those of inert matter, the latter of which were exclusively denominated Physics, while to the former were assigned the appropriate names of *Metaphysics* and *Pneumatology*. This general arrangement, which was founded in an attentive observation of the nature of things, has obtained, in a greater or less degree, in all subsequent ages, and among all civilized nations.

8. One of the most illustrious of our countrymen, Lord Bacon, to whom philosophy owes no ordinary obligations, has proposed a somewhat different classification, which, both on account of its ingenuity and the celebrity of its author, may justly claim our attention. Having stated that "memory, reason (strictly so called,) and imagination, are the three modes in which the mind operates on the subjects of its thoughts;" he adds, "these three faculties suggest a corresponding division of human knowledge into three branches. 1. *History*, which derives its materials from *Memory*. 2. *Philosophy*, which is the product of *Reason*; and 3. *Poetry*, (comprehending under this term all the Fine Arts) which is the offspring of *Imagination*. This arrange-

ment, somewhat varied indeed from the order in which it is stated by the noble author, and rendered more complete in its classification by D'Alembert, one of the well-known authors of the French Encyclopædia, is fully stated, and defended with much ingenuity of reasoning in the Preface to that celebrated work.—*Bac. Op.* Vol. I.

9. Another modern writer of high reputation, the celebrated author of the "Essay on the Human Understanding," has, in the close of that justly-admired Treatise, adopted almost literally the classification of the ancients, though without intimating the source from which it was derived. "All," says Locke, "which can fall within the compass of the Human Understanding, being either,—1st, The nature of things as they are in themselves, their relations, and their manner of operation; or, 2dly, That which man himself ought to do, as a rational and voluntary agent, for the attainment of any end, especially happiness; or, 3dly, the ways and means whereby the knowledge both of the one and the other of these is attained and communicated: I think Science may be divided properly into these three sorts:—

"I. *Physics*, or Natural Philosophy, whereby I mean not only matter and body, but spirits also, which have their proper natures, constitutions, and operations, as well as body. The end of this is bare speculative truth, and whatsoever can afford the mind of man such knowledge falls under this branch.

"II. *Ethics*, or the skill of rightly applying our own powers and actions for the attainment of things good and useful, and conducive to happiness. The end of this is not bare speculation and the knowledge of *truth,* but *right,* and a conduct suitable to it.

" III. *Logic,* or the doctrine of Signs, the business whereof is to consider the nature of those signs which the mind makes use of for the understanding of things, or conveying its knowledge to others. This seems to me," concludes this celebrated author, " the first and most general, as well as natural division of the objects of our understanding."—*Locke's Essay,* b. iv. c. 21.

10. Sir W. Jones, a name not only identified with modern oriental literature, but with the loftiest attainments of human genius, when taking a general survey of the philosophy of the Asiatics, proposes the following classification :—" When man first exerts his powers, his objects are *himself* and the rest of *nature.* Next, he perceives himself to be composed of *body* and *mind* in his *individual capacity,* and in his *social character* possessed of duties and rights, both private and public. Directing his intellect to nature at large, he is led to investigate the *substance* of natural bodies, their several *properties,* and their *quantity* both separate and united, finite and infinite; whence are deduced notions, either purely abstract and universal, or mixed with undoubted facts, bearing the relation of causes and effects, until by this train he arrives at the demonstration of a first *intelligent Cause.* Whence," adds this admirable writer, " his collected wisdom being

arranged in the form of science, chiefly consists of *physiology* and *medicine,—metaphysics* and *logic,—ethics* and *jurisprudence, natural philosophy* and *mathematics,* from which the *religion of nature* (since revealed religion must be referred to *history,* as alone affording evidence of it,) has in all ages and nations been the sublime and consoling result." Agreeably to this division of human knowledge, the learned author proceeds, in his elaborate Dissertations, to treat of the philosophy of the five great Asiatic nations.—*Sir W. Jones's Works,* Vol. I. p. 160.

11. To all the preceding classifications, (except the last, which does not appear to have fallen beneath his notice), the author of the Dissertation, to which we have referred to at the beginning of this section, strongly objects, on the ground of their blending together subjects which are in themselves distinct, and arranging, under the same general head, branches of science the most uncongenial and remote. " *Physics,* he considers as properly restricted to the phenomena of *matter*—the appropriate field of experiment and observation." But *Ethics, Logic,* the *Philosophy of the Mind,* or whatever other objects have been included under the general title of *Metaphysics,* all these are to be regarded as essentially distinct from the former, having to do alone with the phenomena of *mind,* and falling exclusively under the cognizance of *reflection.* Fully convinced of the justice, and even the necessity of this distinction, the author of the following Essays has endeavoured, especially in the more advanced periods of history, to observe this

boundary line, and assign to the physical and intellectual sciences their appropriate divisions.—*Encyc. Brit. New Supp.* Vol. I. Pref. p. 3—17.

SECTION III.

DESIGN AND PLAN OF THE WORK.

12. FROM the preceding introductory remarks, the principal object of the writer of the following pages, in compiling the present work, and the species of information it is intended to convey, will be readily perceived. It professes not to take the entire range of ancient and modern Literature in all its numerous ramifications, for this would require a degree of erudition to which the author can make no pretensions; but merely to exhibit a kind of *bird's eye* view of the most important discoveries of human genius in the departments of Philosophy and Science, marking, as we proceed, the æras when they took place, the persons by whom they were made, and the successive stages of improvement through which they have passed. In attempting this, it will be requisite to attend both to the order of time, and the mutual relation, which the objects of human science bear to each other; and this has constituted the chief difficulty in arranging the plan of the present work. If the chronological order were alone to be regarded, the attention of the youthful reader would be perplexed by a multitude of objects promiscuously presented to his view, and by perpetually

passing and repassing from one department of science to another: if, on the other hand, the proposed classification of the objects of human research were alone to be regarded, a more distinct knowledge might indeed be possessed of each, but their connexion with the history of mankind, and their relative bearings, would not be perceived.* Combining, therefore, as far as possible, both these objects, the following arrangement of subjects will be observed, as that which appears to be upon the whole the most convenient and useful.

I. To divide the whole series of ages, a retrospect of which is about to be taken, into four great periods.

1. That of remote antiquity, "when the cultivation of human knowledge was an exclusive occupation and a separate profession;" the principal records of which are confined to the oriental nations, and have been handed down by tradition from eastern priests and sages.

2. The second period embraces the literary history of the Greeks and Romans, from the first colonization of the Grecian states, to the final dismemberment and dissolution of the Roman Empire.

3. The third will include a brief view of the state of Philosophy and Science, both in Europe and Asia, during the middle ages,—if the logomachies of the scholastics, and the feeble glimmerings of intellec-

---

* A work thus arranged could scarcely be designated a history, however useful it might otherwise be.

tual light that served but to make the surrounding darkness more visible, may be thus designated.

4. The fourth and more important period will bring down the history of human knowledge, and trace the progress of mind, from the revival of letters, which took place about the fifteenth century, to the æra of Locke and Newton, which may be referred to the close of the seventeenth. After this period, the ramifications of science became so numerous, and the field of general knowledge so enlarged, that to take even the most cursory review within the limits which the author has prescribed to himself, would be almost an impracticable attempt. This latter epoch has been fitly termed by a modern writer, " that of the second emancipation of science, in which she appears armed with better instruments, supplied with more abundant materials, and secured alike from attack or decay, by a happier order of society."

II. The literary history of each of the above-mentioned periods will be subdivided :

1. With reference to remote ages and countries GEOGRAPHICALLY, that is, according to the relative positions which the several nations occupied in the map of the world ; for the records of that distant period are so brief and indistinct, that they will scarcely admit of a more minute classification.

2. As we descend the stream of time, and advance to the region of authentic history, the CHRONOLOGICAL order, in which scientific discoveries were

made, or philosophical systems devised, will be more distinctly marked.

3. In proceeding still farther, it will be attempted to sketch the history of the sciences separately, under the two great divisions of *matter* and *mind*, agreeably to the general classification suggested in the last section.

4. In reviewing the latter of the above-mentioned periods, when men of genius and science began to crowd the arena, it will be desirable not only to distinguish the departments of physical and intellectual science, but to notice more particularly the individuals who contributed to their advancement, the order of time in which they flourished, their principal productions, and the influence of their writings and labours, both immediate and remote.

PART I.

ORIENTAL PHILOSOPHY.

SECTION I.

ASSYRIA, BABYLONIA, AND CHALDÆA.

13. IT may be gathered from the most ancient historical document the world has ever known—the Book of Genesis—that considerable progress had been made in the practical sciences before the catastrophe of the universal Deluge. Whence the knowledge of the Antediluvians was derived, and how far it extended, can only be matter of conjectural and hypothetical reasonings; since the brief notices of their history, recorded by the inspired author of the Pentateuch, furnish no data from which certain conclusions can now be drawn. The simple facts are stated, that cities were built, from which some elementary acquaintance with architectural science may be inferred; that certain individuals were artificers in brass and iron, and instructed others in the use of these valuable metals; and that others both constructed musical instruments, and were sufficiently acquainted with the

science of music, to teach others how to "handle" those instruments. Upon the same principles it may not unreasonably be conjectured, especially when the longevity of the patriarchs, and the facilities they possessed for communicating traditional knowledge, are considered, that the same ingenuity which led to these inventions would display itself in many other kindred arts and sciences. Josephus indeed asserts (but on what authority he omits to state), that "longevity was bestowed on them for the very purpose of improving the sciences of geometry and astronomy."

14. After the Flood, the event which occasioned the dispersion of the human family seems to indicate no inconsiderable attainments in scientific knowledge; for, unless a far greater advancement had been made in architecture than has yet been found among uncivilized tribes, the conception could never have been framed of building "a tower whose top should reach to heaven," even after due allowance is made for the boldness of oriental metaphors. Especially will this conclusion appear to be well founded, if, as some have supposed, the principal design of these artificers was, to form a center of union, which might be the basis of an universal monarchy; or, as others have imagined, to construct a lofty observatory for astronomical purposes. To trace the progress of general knowledge among the descendants of Abraham, forms no part of our present plan; because the only authentic sources of information on this subject are found in a volume with which, it is hoped, every reader of this work

will be better acquainted, than with the contents of this elementary history; and also because the few individuals of that nation, who were celebrated for their wisdom or science, stand on the much higher ground of prophetical inspiration. It will be sufficient to remind the juvenile reader, that Moses is said, by the illustrious Proto-martyr Stephen, to have been "learned in all the wisdom of the Egyptians;" that the most scientific as well as most magnificent and costly specimens of ancient architecture were erected in the days of Solomon, and under the direction of that monarch, whose wisdom is said, in Scripture, to have "excelled the wisdom of all the children of the East and all the wisdom of Egypt, so that his fame was in all nations round about. And he spake three thousand proverbs; and his songs were a thousand and five. And he spake of trees, from the cedar of Lebanon unto the hyssop that springeth out of the wall: he spake also of beasts and of fowls and of creeping things and of fishes." (1 *Kings* iv. 30—33.) Of Daniel, the Jewish prophet, who flourished during the captivity, it was confessed, even by a Chaldæan prince, that he was far superior in knowledge to the most learned of his magi, and that "the wisdom of the gods was found in him." It is, however, to be remembered, that in all the three cases just alluded to, their pre-eminence in knowledge is attributed to divine communications and special revelations from heaven.

15. Notwithstanding the pretensions of the Egyptians to have led the way in the march of civilization and general knowledge; and although

it must be admitted, on the authority both of sacred and profane historians, that Egypt was the cradle of some useful arts; there is sufficient ground to dispute the claims of that people to priority, more especially in astronomical science. The *Assyrians, Babylonians,* and *Chaldæans* (names which seem to have been promiscuously employed by ancient writers, to designate the same people), really preceded them by several centuries at least; and many circumstances might be adduced to prove that the Egyptians rather derived the rudiments of knowledge from the Chaldæans, than the Chaldæans from them. Aristotle distinctly asserts, that "the Chaldæan magi were known as a learned sect long before the Egyptian priests;" and it is certain that the Assyrian monarchy, which included the provinces of Babylonia and Chaldæa, had become powerful and flourishing, while that of Egypt was yet in its infancy. Diodorus Siculus, from whose brief and imperfect notices our information on subjects of remote antiquity must be chiefly derived, has clearly attributed the origin of oriental literature to the Chaldæans. The traditions of the Jews, and of almost all other Eastern nations, as stated by Sir W. Jones, abundantly confirm this opinion.

16. But when we speak of the literature of the Chaldæans, the term must be understood as employed in a very limited sense. Some crude and jejune speculations respecting the eternity of matter; a few incorrect and partial observations on the heavenly bodies; and a mass of superstitious notions on judicial astrology, comprehend almost the whole

of the boasted attainments of these learned Chaldæans. With respect to the former of these, they taught, that matter is eternal, never having had a beginning, and never to have an end; that the system of nature does not move spontaneously, nor are its motions directed by blind chance, but under the continual superintendence either of superior or inferior deities; and, finally, that in the beginning, all things consisted of darkness and water, but by divine power, this humid mass was consolidated into a world, and filled with inhabitants. In this Chaldæan cosmogony, it is not difficult to trace a distinct, though corrupted, tradition of the Mosaic account of the creation. If the testimony of ancient writers respecting their knowledge of astronomy can be credited, it was fully equal to what could reasonably have been expected at so early a period, and amidst their great disadvantages. From these sources of information it may be gathered, that they not only discovered six planets, viz. the *Sun*, Mercury, Venus, Mars, Jupiter, and Saturn, and made rude calculations of their several revolutions and orbits; but, according to Petavius, that they determined with tolerable exactness the length both of a synodical and periodical month; according to Hipparchus, that they calculated lunar eclipses; according to Aristotle, that they made many observations on the occultations of fixed stars and planets by the moon's shadow, and grouped the heavenly bodies into imaginary constellations; and also that they divided the zodiac into twelve signs, through which the planets were observed to pass in their revolutions.

Nor do they appear to have been wholly ignorant of the existence of comets, though they considered them rather as meteors than permanent bodies, moving with great velocity through the heavens. But that these astronomical discoveries, if such they may be termed, were mixed with the grossest errors, is evident from the statements of Plutarch and Seneca, who affirm, on the authority of Berosus himself, that they attributed eclipses of the moon to "the turning towards the earth of that part of the lunar globe which is destitute of fire;" and believed that "when all the planetary bodies shall meet in Cancer, the world will be consumed by fire; but when in Capricorn, it will be destroyed by an inundation of water."

17. The most authentic fact relative to this ancient people is, that they were extremely addicted to *judicial astrology,* which was then esteemed the noblest of all the sciences. To this all their astronomical observations were rendered subservient. From the motions and relative positions of the planets—the manner of their rising and setting—the degree and colour of their light—from the appearance of comets and meteoric lights—from eclipses of the sun and moon;—in a word, from all the ordinary and extraordinary phenomena which presented themselves, the Chaldæan Magi uttered their oracular predictions respecting the rise and fall of empires, the good or ill success of battles, as well as the fortune of private individuals. As a basis for these astrological predictions, it was maintained that the six planets (which they called Interpreters,

because they portended by their aspects the will of the gods,) maintained a continual correspondence with thirty stars, which they termed *Counselling Deities*, half of whom took cognizance of the things of earth, and the other half of what is transacted in the heavens; that once in ten days one of the superior stars descended to the inferior, to communicate the will of the gods; and, in return, at stated periods, the inferior ascended to the superior, to convey intelligence from earth;—that the chiefs of these *counselling deities* were twelve principal stars, one of whom reigned for a month, and to each of whom was committed one of the signs of the zodiac. Such is, in brief, the explanation given by Diodorus Siculus of the Chaldæan system of astrology, and so truly has an inspired Apostle affirmed, when alluding to the delusions of heathen philosophy, that "esteeming themselves *wise*, they became *fools*."

18. But however defective may have been the knowledge of these primitive astronomers, or however misapplied their few and partial discoveries, it is to be remembered, that to them posterity is indebted for its elementary acquaintance with a science of all others the most sublime. The period to which the present section refers, must be considered as the earliest dawn of astronomical science. In Chaldæa is found the source of that stream of knowledge which modern discoveries have expanded into an almost interminable ocean. Disposed as we may sometimes feel to treat with contempt the oracular prognostications of the Chaldæan astro-

logers, classing them with the fortune-tellers of modern times, it should not be forgotten, that even the rude and inaccurate calculations by which they pretended to foretell the destinies of mankind, prepared the way for the astonishing developments of later ages. To this subject may not unfitly be applied the remarks of a distinguished living writer, with reference to the gradual development of the human character. "The smallest thing," says Foster, "becomes respectable, when regarded as the commencement of what has advanced, or is advancing, into magnificence. The first rude settlement of Romulus would have been an insignificant circumstance, and might justly have sunk into oblivion, if Rome had not at length commanded the world. The little rill near the source of one of the great American rivers is an interesting object to the traveller, who is apprised, as he steps across it, or walks a few miles along its bank, that this is the stream which runs so far, and gradually swells into so immense a flood."—*Foster's Essays,* Vol. I. p. 7.

19. The departments of Chaldæan literature already alluded to, together with other modes of divination, were among the occult sciences studied alone by the sect of the Magi; on which account they were all comprehended under the general title *Magic.* But there is ground to believe that there were other practical sciences, of far greater utility, in which the ancient Babylonians made considerable advances. If the accounts transmitted by ancient historians, relative to the magnitude and splendour

of the cities of Nineveh and Babylon, be correct; if those ancient cities contained such massive walls, such elevated towers, such spacious and magnificent temples and palaces, as tradition has reported; there must have existed at that period architects and practical mathematicians of no mean reputation. From the great variety of musical instruments said to have been employed at the dedication of Nebuchadnezzar's colossal image, and, indeed, from the construction of the image itself, may be inferred their skill in mechanism; and, finally, the celebrity of the manufactures of ancient Babylon, the rich embroideries, sumptuous vestments, magnificent carpets, and fine linen, said to have been exported thence into distant parts of the world, sufficiently prove that arts and industry prevailed among its inhabitants.

20. Of the men of letters, who flourished in Babylonia and Chaldæa, little is now known. The names of a few individuals of this class have indeed been preserved, but their works have long since perished. A Chaldæan philosopher, named *Zoroaster*, is mentioned by ancient writers, who must be distinguished from the *Zoroaster*, or *Zerdusht*, so celebrated in Persian history. He is supposed to have been contemporary with Abraham, the founder of the Magian sect, and the inventor of magic, or, as it has since been designated, judicial astrology. The records of antiquity contain a few scattered fragments of the works of *Berosus*, a Chaldæan historian, who flourished about the time of Alexander. He wrote an ancient history of the world, ending A.C. 267, which is referred to by Josephus,

and also by some of the Christian Fathers, as confirmatory of the truth of the Old Testament history. By some it is called the *Babylonica,* and by others the *Chaldaica,* of Berosus. It consisted of three books, including the history of the Babylonians, Medes, and Persians. According to Josephus, Berosus reckons ten generations between the first man and the Universal Deluge, and marks the duration of each of these generations by periods of 223 lunar revolutions, which, reduced to years, nearly accord with the chronology of Moses. The fragments of this ancient document, which still exist, are contained in the writings of Josephus and Syncellus, who seem to have collected them with much exactness. A clumsy attempt was made, in comparatively modern times, by an obscure monk, named Annius of Viterbo, to produce and impose on the world a fictitious history of Chaldæa, under the name of Berosus; but the attempt has only served to entail disgrace upon its author.—Vid. *Enfield's Abridgment of Brucker's History of Philosophy,* Vol. I. p. 25—37.

SECTION II.

CHINA.

21. ALTHOUGH it is impossible to determine the geographical boundaries of the ancient Assyrian empire, it is known to have been, during the period of its greatest prosperity, of vast extent, including

within its limits many large and populous provinces. Among these, there is little reason to doubt that China, and India, both within and without the Ganges, were included. "The different nations," says Sir W. Jones, "who have, in different ages, divided among themselves, as a kind of inheritance, the vast continent of Asia, with the many islands depending on it, are the five following:—the Indians, the Chinese, the Tartars, the Arabs, and the Persians: who they severally were—whence and when they came—where they now are settled—and what advantage a more perfect knowledge of them all may bring to our European world, will be investigated, and the great problem solved, whether they had *any common* origin." To this latter opinion, that learned writer accedes, and adduces many ingenious arguments in its defence. This fact (if it may be deemed such) will not only account for the early civilization of the eastern provinces of Asia, and for the similarity of their customs, manners, and dialects, but also for the particular direction which the human mind seems to have taken in its pursuit of knowledge, and the sciences cultivated by them from remote antiquity. A striking resemblance may be perceived in their mythological fables, their metaphysical speculations, and their scientific pursuits, which goes far to prove their common origin, whatever may be the opinion of antiquarians respecting their priority. Without presuming to determine whether China or India should take the precedence in chronological order, our attention, in this survey of ancient literature, will be first directed to China, on account of its confessed antiquity and national importance.

22. A veil of impenetrable obscurity hangs over the primitive history of this vast empire, which the utmost diligence of research has not been able to remove. Many conjectures have been made respecting the probable origin of this singular portion of the human race, and many plausible theories devised by men of ingenuity and learning; but all have been unsuccessful in attempting to establish, on the basis of authentic history, either the period in which the Chinese empire was founded, or the source from which its vast population was immediately derived. The fables of the Chinese themselves, on this subject, are wholly undeserving of credit, nor are the tales of the jesuit missionaries, who have long dwelt among them, and flattered their national vanity for interested purposes, more credible. The theory of Sir W. Jones, already alluded to, who considers this people as one great branch of the five Asiatic nations, which were primarily consolidated in one mighty empire, to which he gives the name of *Iran,* (probably the *Assyrian,*) appears on the whole most satisfactory, because it serves best to explain the phænomena of their intellectual and moral resemblances, it accords best with scripture history, and it accounts most satisfactorily for the monotheism which prevailed there during many ages.—*Sir W. Jones's Works,* Vol. I. p. 21.

23. Notwithstanding the high pretensions of this people to literary eminence in very remote ages, there is little reason to suppose, that the arts and

sciences, and still less that any thing which may deserve the name of philosophy, had made any considerable progress among them before the time of *Kung-footsze*, (or, as latinized by the Catholic Missionaries, *Confucius*,) who flourished about six centuries before the Christian Æra, and to whom we are indebted for the earliest authentic information respecting the history and antiquities of China. According to the traditional history of the Chinese themselves, their first princes invented agriculture, music, medicine or the healing art, and astronomy. It is also asserted, that theology, ethics, and natural philosophy, were their favourite studies, and that they were the original instructors of mankind in the mechanical arts, particularly architecture and navigation. But all these have been proved by Sir W. Jones, and other European writers in modern times, to be unfounded pretensions, originating in national vanity, and supported by popular ignorance. There is rather ground to conclude, that their first efforts in science were extremely rude and imperfect, and that their literature was truly contemptible. The most judicious and best informed of modern Chinese scholars concur in the opinion, that no authentic records exist of the times to which these traditions relate, and that they are to be esteemed altogether fabulous. It may however be deserving of notice, that among their most ancient traditions, is that of a general deluge, said to have taken place at a period corresponding with A. C. 2200; and that they carry back their antediluvian traditions to a much earlier period. Thus do we obtain, from another independent source, an additional confirmation of Sacred History.

24. The ancient literature of China is stated, by Dr. Morrison (to whose various and valuable writings on the subject the author is chiefly indebted for the contents of this section), to consist of the writings or compilations of the moral philosophers of the age of Confucius, with numerous notes and comments and paraphrases on the original text, the productions of subsequent ages, and with controversies concerning its genuineness, the order of particular words or phrases, and the meaning of obscure passages, which still continue to exercise the critical acumen of Chinese scholars. The text of the *Woo-king*, or *Five Sacred Books*, written or compiled by Confucius himself; and of the *Sze-shoo*, or *Four Books*, compiled by four of the disciples of Confucius, (and from which circumstance they receive their title,) contain the doctrines and precepts which Confucius approved and taught. "In respect of external form," says the same learned writer, "the Five *Books* of the Chinese correspond to the Pentateuch of Moses; and the Four Books, in respect of being a record of the sayings of a master, compiled by four disciples, have a slight resemblance to the Four Gospels. But the contents—how different! with the exception of a few passages in the most ancient part of the *Woo-king*, which retain something of the knowledge which Noah must have communicated to his children, the rest appears a godless system of personal, domestic, and political moralities, drawn only from the pride of the human

heart, the love of fame, or present expediency. The sanctions of the Eternal and Almighty God, arrayed with every natural and moral perfection—the fears and hopes of immortality—the love and grace of a Saviour—are wholly wanting in these ancient Chinese works, which yet are " deemed by millions of the human race most sacred."—*Morrison's Chinese Miscellany*, p. 34.

25. As the works to which we have just referred constitute the prominent and most important feature of ancient Chinese literature, the following outline of their principal contents may not be unacceptable to the juvenile reader.

" The first of the *Woo-king*, or *Five Sacred Books*, consists of ancient love songs—political satires, in verse—concealed censures of eminent persons—the praises of the virtuous—the regret of soldiers on the frontier—occasional delineations of nature, and expressions of feelings. Of the odes in this ancient book, there are 301 ; and for the perusal of them all, Confucius gave one rule in three words, denoting *purity of mind*."

The second is a sort of chronicle of the deliberations between two ancient *chieftains*, or emperors, and three kings. It originally consisted of 100 sections, but 58 only are now extant. It is believed to contain all the principles of good government, which are comprehended in four words, nearly corresponding with the English words,—Virtue—Benevolence — Gravity — Sincerity. In this book are also found some records of ancient traditions.

The third is of a more metaphysical character, and contains the doctrine of *changes*, or *alterations*, founded on the system of *Dual Powers in Nature.* The philosophy of this book bears a strong resemblance to the unintelligible jargon of the scholastics. From its chaos of absurdity, Dr. Morrison has endeavoured to gather something like form and order, and concludes, that "the theology it teaches is a species of atheistical materialism."

The fourth consists of ancient ceremonials, both civil and religious, prescribed rules for regulating behaviour, dress, marriages, burials, sacrifices, sacred places, prescribed forms of worship, &c. &c. On this ancient system of ethics, it is remarked, that it places self-respect and respect for others, a seriousness of mind and deportment, and gravity of speech, at the foundation of the whole. There are no references to any divine law or sanction, as constituting the grounds of moral obligation.

The fifth of these ancient books is said to have been the only one composed by Confucius himself; those already mentioned having been compilations from still more ancient documents. It is a sort of history of his own times; or, as modern Chinese scholars have termed it, "a bold chronicle of public occurrences," or a species of Annual Register, bearing the fanciful title of *Spring and Autumn.—Chinese Miscell.* p. 37—42.

26. Next in antiquity and importance to the *Woo-king* is the *Sze-shoo,* or Four Sacred Books, which contain the recognized principles of the Confucian school; a work which, though composed of the most fanciful and unfounded theories in

nature, religion, morals, politics, medicine, and other subjects of science, is said to exhibit, as a whole, a most beautiful and well-arranged system, the knowledge of which is indispensable to the attainment of any station of honour or emolument in the Chinese empire. "In these Four Books, knowledge is considered as fundamental; not merely intellectual knowledge, but chiefly what they call a clear discernment of illustrious virtue—an accurate perception of nature's light, connected with a sincere application of this knowledge to the moral improvement of the individual. Next comes its application to the benefit of others; or, as they express it, "to the renovation of the people:" and, finally, "a constant steady adherence to the principles and practice of the virtues previously ascertained." The gradations of society, as sketched in these ancient documents, are—1. The cultivators of the mind, or men of philosophy and science; 2. The cultivators of the land, or practical agriculturists; 3. Operators on the earth's produce, or the artizans and mechanics; and, 4. The transferrer of commodities, or the mercantile classes. The first of these classes has been for many ages the most privileged, retaining in full possession the power of administering the "*Celestial empire.*"—*Chinese Miscell.* p. 43.

27. From the preceding sketch of the subjects to which the works of Confucius and his disciples relate, it will be perceived, that the ancient literature of China was rather metaphysical and ethical, than connected with the practical sciences or the

phænomena of nature. It abounded with abstract speculations, moral aphorisms, and didactic rules for individual or social conduct. The summary of the ethical system of Confucius, as gathered by Sir William Jones from the writings of that philosopher, is, that "he who shall be fully persuaded that the Lord of heaven governs the universe — who shall in all things chuse moderation — who shall perfectly know his own species, and so act among them, that his life and manners may conform to his knowledge of God and man — may be truly said to discharge all the duties of a sage, and to be far exalted above the common herd of the human race." Such may have been, from remote antiquity, the tenets maintained and inculcated by the philosophers of China: but from other sources of information it may be gathered, that in that empire, as in all other pagan countries, there were gods many, and lords many; and that the superstitions of the common people were encouraged, rather than counteracted, by the speculative philosophers. The multitude have, from time immemorial, believed in the agency of subordinate deities, genii, and tutelary spirits, presiding over the stars and clouds—over lakes and rivers—mountains, valleys, and woods—over certain regions and towns—over all the elements (and especially *fire*, the most brilliant of them all): and to these deities they offered victims on high places. A distinction must therefore be made in China, no less than in India and Greece, between the speculative theories of the learned, and the gross superstitions of the vulgar.

28. The only department of physical science, in which the Chinese are known to have made any considerable progress in remote ages, is ***Astronomy:*** but by them, as well as by the Chaldæans, and almost every other oriental nation, this noble science was degraded by its supposed connexion with astrology. Both the Chinese annalists and the jesuit missionaries trace back the history of astronomy in China to the age immediately succeeding the universal deluge. They attribute to Fo-hi, their first emperor (whom some suppose to have been *Noah,* and others *Ham*), the discovery of the elementary principles of their science, the invention of the signs of the zodiac, the arrangement of the constellations, &c. P. Gaubil, who seems to have investigated more closely the claims of the Chinese astronomers, admits, that at least as early as A.C. 120, the number and extent of the constellations had been determined as they now stand;—the situation of the fixed stars, with reference to the solstitial and equinoctial points, and the obliquity of the ecliptic;—that, about the same time, the theory by which they foretold eclipses, was discovered and acted upon, and that there are still extant in their language, treatises on astronomy, which were written two hundred years before the Christian Æra.

29. Before we quit this vast and populous empire, the literary history of which is daily becoming better known and more interesting to Europeans, a cursory view may be taken of the principal departments of its modern literature, as arranged by Dr. Morrison in his valuable Chinese Miscellany.

After enumerating the ancient writings of Confucius and his disciples, it is stated, that "the 1st class includes the multitude of modern critics and commentators on those writings; 2. Histories of the Chinese Empire, which are numerous, written in a grave style, and interspersed with remarks on the persons and occurrences which pass in review; 3. Historical novels, which now constitute a favourite department of Chinese reading; 4. Dramatic works, generally published under fictitious names; 5. Poetry, which consists chiefly of short descriptions, expressing the tender or mournful feelings of the heart, and sometimes describes rural scenery, but seldom touches on moral subjects; 6. The Collectanea of political, philosophical, and controversial disquisitions forms a very numerous class of modern Chinese writings; 7. Geographical and topographical treatises are abundant; 8. Medical works on the theory and practice of the healing art are also said to be numerous, and highly curious; 9. Astronomical books, which generally are filled with the dreams of astrology, intermingled with scientific information; 10. The Prize Essays of many generations, which are preserved, and published with care at the expense of the government; and, 11. The moral and religious essays of the three modern Chinese sects," termed by Dr. Morrison, "the Confucian School of Atheistical Materialists, the Visionary Alchymic School of Laokeun, and the Hindoo Polytheistic School of Buddha."—*Morrison's Chinese Miscellany*, p. 36.

SECTION III.

INDIA.

30. THE same obscurity which hangs over the primitive history of China, veils also that of the peninsula of Hindostan. But from whatever quarter the inhabitants of these oriental climes (now rendered so interesting by their political relation to ourselves) may have derived the elements of their civilization and knowledge, it is certain that there existed among them, from the earliest period of their traditional history, men highly reputed for their wisdom and erudition; and that discoveries were made by them in moral and physical science, which, though they may not bear a comparison with the developments of modern times, are yet, when viewed in connexion with the existing state of society, truly astonishing. So high was the literary reputation of this people, long before the arts and philosophy flourished in Greece, that all who made any pretensions to learning in that country deemed it necessary to visit India, that they might make themselves acquainted with the philosophical systems, and scientific discoveries, for which the eastern sages were renowned. An ancient Greek historian affirms, that " the Indians were the wisest of nations, especially in moral science; and notwithstanding the national vanity of the Greeks, which led them to pour contempt on all other nations as barbarous, the confession is frequently extorted from them, that

the most celebrated of their philosophers were greatly indebted to their travels among oriental nations for their high attainments in knowledge. "The six philosophical schools," says Sir W. Jones, "whose principles are explained in the Dersana Sastra, comprise all the metaphysics of the Old Academy, the Stoa, the Lyceum; nor is it possible to read the Vedanta, (another of the ancient Indian Sastras,) or the many fine compositions in illustration of it, without believing that Pythagoras and Plato derived their sublime theories from the same fountain with the sages of India."

31. Of the philosophy of India it would be impossible to give even a faint outline in this summary of ancient literature; nor is it easy to form a decided opinion of its general character, amidst the jarring opinions entertained on the subject by writers possessed of ample means of information. By some it has been described as a compound of fanatical metaphysics, and extravagant superstitions, without the smallest seasoning of rational physics; while others have represented it as a refined allegorical system of metaphysical theology, characterized by ingenuity and pre-eminent genius. Without acceding fully to either of these contrary opinions, it may be safely affirmed, that the mystical philosophy of India approaches much nearer to reason and truth than the bold and impious speculations of the modern European philosophers. The latter have strenuously laboured to exclude mind from the universe; but the ancient Hindoo philosophers, proceeding to the opposite extreme of *pantheism,* allow no powers

whatever to material substances, but introduce the Deity as the immediate cause of every effect, however trivial; as the agent and author alike of good and evil. "From all the properties of man and nature—from all the various branches of science—from all the deductions of human reason, the corollary drawn by all the philosophers of the East is, the supremacy and direct agency of an all-creating, all-preserving spirit, infinitely wise and powerful, but infinitely removed, also, from the comprehension of his most exalted creatures. In common with all other eastern nations, they considered the human soul as a particle or an emanation of that intellectual fire by which the universe is animated. To the same source may also be referred their belief in transmigration, re-absorption in the Divinity, and the periodical renovation of the material universe."*

32. No early traces of moral science, considered

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* The statement of Sir W. Jones, respecting the branch of Hindoo philosophy referred to in the text, exhibits it in a more favourable light. "The fundamental tenet of the Vedanti School consisted, not in denying the existence of matter, that is, of solidity, impenetrability, and extended figure, (to deny which would be lunacy,) but in correcting the popular notion of it, and in contending that *it has no essence independently of mental perception*—that existence and perceptibility are convertible terms—that external appearances and sensations are illusory, and would vanish into nothing, if the divine energy, which alone sustains them, were suspended but for a moment; an opinion which Epicharmus and Plato seem to have adopted, and which has been maintained in the present day (alluding to the well-known Berkleyan system,) with great elegance, but with little public applause."—*Sir W. Jones's Works*, Vol. I. Prelim. Diss.

as a *system*, can be found among the ancient writings of the Hindoo philosophers; but their *Sastras*, or sacred books, abound with ethical maxims and preceptive rules of conduct.

The moralists of the East have in general chosen to deliver their precepts in short sententious aphorisms, to illustrate them by allegorical comparisons, or to inculcate them in the ancient form of apologues or fables. The *Niti Sastra*, or *System of Ethics*, still held in high veneration by the inhabitants of India, contains, amidst many absurdities, a great mass of moral instruction; and the fables of Vishnu-serman (better known by the name of *Pilpay*) are said to be the most beautiful, if not the most ancient, collection of apologues in the world. These fables were originally written in the Sanscrit dialect, under a title which signifies "amicable instruction;" from which they were first translated into the popular language of India, in the sixth century. They are now extant in more than twenty of the oriental dialects, and greatly admired for the moral wisdom they contain. It is conjectured by Sir W. Jones, that, "as the very existence of Esop is doubtful, the first moral fables known to the Europeans, were of Indian or Ethiopic origin."—*Sir W. Jones's Works*, Vol. I. p. 32.

33. Physical science seems to have been chiefly applied by the ancient Hindoos, either to the conveniences of social life, or to the more disgraceful purpose of magical and astrological imposture. If full reliance could be placed on their own traditional history, or the testimony of some distinguished

modern writers, it would appear that the most remarkable discoveries were made by them, even in the infancy of society, in the kindred sciences of arithmetic, algebra, geometry, and astronomy. That they were early famed for their skill in navigation and their astronomical knowledge, is evident from the writings of the ancient geographer, Dionysius, who describes them as a people,

"——— who *first* assay'd the deep,
And wafted merchandize to coasts unknown;
Those who digested *first* the starry choir,
Their motions mark'd, and call'd them by their names."

Yet more decisive evidence is adduced of their attainments in astronomy by a scientific modern writer (Bailly), who examined attentively the astronomical tables of the Indian philosophers of antiquity, and asserts, that they are far superior in accuracy to the best calculations of the Grecian astronomers. The fundamental epoch of the Indian astronomy is a conjunction of the sun and moon, which, according to their chronology, is said to have taken place at a period nearly corresponding with the year 3102 before the Christian Æra; and the most accurate calculations of modern astronomers have shewn, that such a conjunction must have actually taken place at that time. Still more remarkable is the statement of Sir W. Jones, who refers to the works of an ancient philosopher of India, which are said to include a system of the universe, founded on the principle of attraction, and the central position of the sun; whence he infers, that this Indian philosopher (probably a contemporary of Pythagoras) communicated to the philosopher of Samos that knowledge of the true solar system, which he is said to have possessed.*

34. On the general literature of the ancient Hindoos, the following brief notices may suffice. Numerous treatises are found among their ancient writings on grammar, rhetoric, logic, music, medicine, geography, and history, which, though little

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* In proof of this statement (viz. that the philosophers of India were not ignorant of the great law of attraction), Sir W. Jones has adduced, from an ancient allegorical poem, the following curious passage:—"There is a strong propensity which dances through every atom, and attracts the minutest particle to some peculiar object; search this universe from its base to its summit, from fire to air, from water to earth, from all below the moon to all above the celestial spheres, and thou wilt not find a corpuscle destitute of that natural attractability; the very point of the first thread in this apparently tangled skein is no other than such a principle of attraction, and all principles beside are void of a real basis; from such a propensity arises *every motion* perceived in heavenly or in terrestrial bodies; it is a disposition to be attracted, which taught hard steel to rush from its place, and rivet itself on the magnet; it is the same disposition which impels the light straw to attach itself firmly on amber; it is this quality which gives *every substance in nature a tendency toward another*, and an inclination forcibly directed to a determinate point." "These notions," remarks the learned author of the Dissertation on the Philosophy of the Hindoos, from which the above passage is quoted; "these notions are vague indeed and unsatisfactory; but permit me to ask whether the last paragraph of Newton's incomparable work goes much farther, and whether any subsequent experiments have thrown light on a subject so abstruse and obscure."—*Sir W. Jones's Works*, Vol. I. p. 171.

known to European scholars, are affirmed, by no incompetent witness, to "evince a fertile and inventive genius; their lighter poems, some of which are of high antiquity, are lively and elegant; their epic, magnificent and sublime in the highest degree. The ancient books, called *Puranas,* comprise a series of mythological histories, in blank verse, from the creation to the supposed incarnation of Buddha; and their *Vedas* abound with noble speculations in metaphysics, and fine discourses on the being and attributes of God." To this perhaps too flattering statement of the contents of these ancient writings, it is requisite to add (on the authority of the late excellent missionary, Ward, author of a valuable work on the Customs, Manners, and Superstitions of the Hindoos), that these sublime speculations and moral maxims are blended with and degraded by the most absurd fictions and the grossest obscenity.

It is painful to be under the necessity of closing this brief sketch of the ancient learning of India, with the assertion, that these boasted attainments in philosophy have hitherto presented the most formidable barrier to the introduction of Christianity among its inhabitants, and that, while the unlettered and more barbarous tribes of Africa, or the islanders of the Pacific, have renounced the superstitions of their forefathers, the haughty Brahmins of India (with but few exceptions), clad in the proof armour of metaphysical theology and worldly wisdom, have remained impervious to the light of christian revelation, and continued proudly to reject the "wisdom that comes from above." Happy were it for them, and for the world, if the advice with which one of their own *Shastras* concludes were but practically obeyed:—" *That Spirit, from* which all created beings proceed; *through* which, having proceeded from it, they live; *toward* which they tend; and *in* which they are ultimately absorbed;—*that Spirit study to know:* that Spirit is the GREAT ONE."—*Sir W. Jones's Works,* Vol. I. pp. 173, 174.

SECTION IV.

PERSIA.

35. IF Persia were, as Sir W. Jones has asserted, " the true center of population, of knowledge, of languages, and of arts," in a very remote period of antiquity; and if from that empire civilization and learning travelled in every direction throughout the vast continent of Asia, a more than ordinary degree of importance must attach to its primæval history. Even the most indistinct records of its ancient literature must possess an unwonted interest, not only on their own account, but still more because of the relation they bear to the progress of knowlege in subsequent and far distant ages. It is much to be lamented, (though it is not difficult to account for the fact,) that the early history of so distinguished an empire should be so little known, and that the traditions respecting it should be so various and contradictory. A few of the most credible

statements and opinions on this interesting subject will be embodied in the present section, gathered from the most authentic sources of information to which its writer could obtain access. It is to be premised, that Religion and Philosophy are so blended together in the history of ancient Persia, that, though the former falls not distinctly within the object of the present work, it will be impossible to separate the one from the other. The few distinguished names which occur in the annals of its ancient literature, were chiefly celebrated as *religious reformers*, who, by their instructions and their writings, propagated those tenets on moral subjects, and instituted those religious rites, which continued to prevail during many ages.

36. It is generally admitted, that long before the time of the celebrated Zerdusht, or Zoroaster, the Magian sect existed in Persia, and included men of reputed learning, held in high veneration by the common people; but it is probable that, in Persia as in Chaldæa, their only erudition consisted in such rude calculations respecting the phænomena of the heavenly bodies as enabled them more successfully to practise the arts of delusion, by pretending to augur, from the aspect of the heavens, the destinies of mankind. Some faint traces may indeed be perceived of an earlier and purer state of society, bearing a close resemblance to the patriarchal. The primæval religion of Persia is said, on the authority of some oriental writers, to have been "the oldest and noblest of all religions. It consisted in a firm belief that one supreme God made all things by his

power, and continually governs them by his providence—in a pious fear, love and adoration of Him—a due reverence for parents and aged persons—a fraternal affection for the whole human species, and a compassionate tenderness even for the brute creation." This purer form of moral and religious belief was, however, gradually corrupted and debased, and there was grafted upon it the *Sabian* superstition, which was probably imported from India, and consisted in the adoration of the host of heaven, or the worship of the celestial bodies: hence arose numerous temples in Persia, dedicated to the sun and planets, and containing symbolical representations of those objects of their idolatrous homage; some memorials of which are still preserved among the specimens of Persian sculpture. This popular religion seems to have originated with Mahabad, who is said to have been the first monarch of Persia, and of whom tradition relates, that "he received from the Creator, and promulgated among men, a *sacred book in a heavenly language*, which consisted of regulations and divine ordinances for the conduct of mankind." In these traditions, a clear indication is given, that some knowledge was preserved and widely diffused of the *primitive revelation;* and hence some have been led to imagine, that *Abraham* or *Moses* was the real person intended by the Persian *Mahabad.* A partial reformation of the popular faith was subsequently effected, about the ninth century before the Christian Æra, by *Hushang*, which, while it rejected the grosser forms of polytheism that had been gradually introduced, and revived the laws and institutions of Mahabad, encouraged a superstitious veneration for the celestial bodies.

37. It is not, however, till we arrive at the æra of Zerdusht, that we find ourselves on the firm ground of authentic history. This celebrated Persian philosopher is to be distinguished both from the Chaldæan philosopher of the same name (to whom we have already referred), who flourished at a much earlier period, and from several others mentioned by ancient writers who lived after him. Stanley, in his Lives of the Philosophers, affirms, "that ancient history mentions several Zoroasters; the first, a Chaldæan; the second, a Bactrian; the third, a Persian; the fourth, a Pamphylian; and the fifth, a Proconnesian: all of whom were said to be the principal founders of the literature of their respective countries." If this statement be correct, it would seem probable, either that all these traditions had one common origin, and referred to the same individual; or that the name was anciently employed, as a kind of literary title, to designate those persons who rendered themselves famous by their wisdom and learning. Whether this opinion be well founded or not, there can be no doubt of the existence and celebrity of the Persian *Zoroaster*, or, as he is called by the orientals, *Zerdusht;* and that he flourished during the reign and under the patronage of *Darius Hystaspes.* This ancient sage is said to have exerted his influence and learning for the purpose of counteracting the popular superstitions of his country, and to have produced a great

reformation, amounting almost to a revolution, both in philosophy and religion. To the character of a literary reformer, his pretensions seem to have been well founded; but it may be doubted, if what has already been affirmed respecting the primitive religion of Persia be correct, whether he can claim, on just grounds, the higher honour of a religious reformer.

38. For a summary of the philosophical and religious tenets and maxims of Zoroaster, it is requisite to refer to his writings, some of which are still extant, but the far greater part have perished. The sacred book, called the *Zend*, still held in high veneration by the Persians, has been generally attributed to him, though some critics consider it the production of a much later period. This book consists of two parts, one of which contains the forms of devotion and ceremonies to be observed in religious worship; the other, precepts of religion and morality. A portion of this ancient book is read to the people on every sacred day by the priests; and from its pages are derived many of the metaphysical speculations which still exercise the ingenuity of the learned. Many works in astrology, physics, and theology, are also said to have been written by Zoroaster, and are occasionally referred to by modern oriental scholars, no traces of which remain. One curious document, however, still exists, consisting of fragments of his supposed writings, under the title of the *Oracles of Zoroaster*. They are in verse, and, notwithstanding all the labours of the Platonic Philosophers, several of whom wrote large commentaries upon them, extremely

obscure. If these are genuine productions of the Persian philosopher, they distinctly point out the true origin of the philosophy of Plato.

39. The outline of the Persian philosophy, or rather of that system of metaphysical theology, which has been professed immemorially by the *Sufis*, or Persian literati, is thus sketched by the masterly hand of Sir W. Jones, than whom scarcely an individual can be found in modern times more intimately acquainted with the literature of Persia. "Their fundamental tenets are, that nothing exists absolutely but God: that the human soul is an emanation from his essence; and though divided for a time from its heavenly source, will be finally re-united with it; that the highest possible happiness will arise from its re-union, and that the chief good of mankind in this transitory world consists in as perfect an union with the eternal Spirit, as the incumbrances of a mortal frame will allow,—that for this purpose they should break all connexion with extrinsic objects, and pass through life without attachments, as a swimmer in the ocean strikes freely without the impediment of clothes; that they should be straight and free as the cypress, whose fruit is hardly perceptible, and not sink under a load like fruit-trees attached to a trellis—that if mere earthly charms have power to influence the soul, the idea of celestial beauty must overwhelm it in extatic delight,—that for want of apt words in which to express the divine perfections, and the ardour of devotion, we must borrow such expressions as approach the nearest to our ideas, and speak of Beauty

and Love in a transcendent and mystical sense; that, like a reed torn from its native bank,—like wax separated from its delicious honey,—the soul of man bewails its disunion with *melancholy music*, and sheds burning tears, like the lighted taper, waiting passionately for the moment of its extinction, as a disengagement from earthly trammels, and the means of returning to its Only Beloved." "Such," adds this elegant writer, "is the wild and enthusiastic religion of the Persian poets, especially of the sweet Hafiz, and the great Maulavì; such is the system of the Vedanti philosophers, and best lyric poets of India; and, as it was a system of the highest antiquity in both nations, it may be added to the many other proofs of an immemorial affinity between them."—*Sir W. Jones's Works*, Vol. I. pp. 90, 91.

40. Truth, however, demands that it should be distinctly stated, that the preceding sketch of the Persian philosophy exhibits not its grosser features. With these refined speculations on the nature of the human soul, and its re-absorption in the Divinity, were blended, by the great Persian reformer himself, many mythological fables relative to the two opposite principles of *good* and *evil*, (the former of which was personified under the name of Oromasdes, and the latter under that of Arimanius); respecting the genii, or angels, supposed to preside over months and days; respecting the adoration of the Sun, as the brightest emblem of Mithra or the Supreme Deity, and of Fire, as the offspring of the sun and an emanation from his magnificent orb. Whether Zoroaster taught, and his disciples practised,

the worship of the Sun, and of the element of Fire, has been much questioned in modern times, though it seems to have been generally believed by the ancients. It is stoutly denied by the Persian Sufis of the present day, who appeal to supposed writings of great antiquity in proof of their assertions. In one of these, the following explanation is given of the act of Cyrus, in prostrating himself before the blazing altar:—"Think not, that they were *adorers of fire,* for that element was only an exalted object on the lustre of which they fixed their eyes; they humbled themselves a whole week before God; and if thy understanding be ever so little exerted, thou must acknowledge thy dependance on the Being supremely pure."*—*Sir W. Jones's Works,* Vol. I. 90.

41. The veneration in which the sun and other celestial bodies were held by the ancient Persians

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* In further confirmation of this opinion, Dr. Hyde relates, that when a Persian priest was interrogated by an intimate friend of his, then resident in India, "At what seasons and with what ceremonies they adored the sun?" he replied, that "neither they nor their fathers had ever worshipped the sun, or paid any divine honours whatever to that luminary, to the moon, or to the planets; but only turned themselves toward the sun when praying, because they considered it as coming nearest to the nature of fire, and the brightest image of the Divinity." From these facts—if such they may be called—it must be evident, that *Theism,* or the worship of the one living and true God, has been preserved, (not indeed unmingled with corrupt and superstitious rites, but yet in some degree of purity,) from the earliest records of the Persian empire to the present time. Additional evidence on this interesting subject, may also be obtained from the "Life and Remains of the late excellent and lamented Missionary, Henry Martyn."

(whether it amounted to religious worship or not), naturally led them to the study of astronomy. They were prompted by their religion, no less than by curiosity and the desire of knowledge, to make as minute observations as their limited means would permit, on the orbits, motions, and other visible phænomena of the heavenly luminaries. Instructed probably by the Chaldæan Magi, they established "a number of artificial cycles with distinct names, which seem to indicate a knowledge of the period in which the equinoxes appear to revolve;" and from the same source, it is probable that those elements of physical science were derived, which obtained for them the reputation of magicians and enchanters. But whatever may have been the learning possessed by the Persian Magi, it was carefully concealed from public view, and confined to their own privileged order. None except the members of the royal family were among the initiated.

42. Few monuments of antiquity remain to indicate the progress of the arts in ancient Persia; but of those few, some are exquisitely beautiful. Among the venerable ruins of Persepolis, and other sculptured remains discovered by modern travellers, are found architectural specimens, which, while proved by their state of decay to have been executed in very remote ages, prove also, by their scientific proportions and tasteful decorations, that the fine arts had made no inconsiderable progress in Persia. Mohsan, a learned Persian writer, frequently cited by Sir W. Jones as a most credible witness, affirms

that there still exist in Persia, and its adjacent countries, numerous fragments of ancient poetry written in the *Pahlàvi,* or old Persic dialect, some of which are believed to have been the production of Zerdusht himself, or of his immediate disciples. A considerable collection of Persian MSS., confessedly of great antiquity, have been imported into Europe by eastern travellers, the most valuable of which are deposited in the Royal Library at Paris. These books, written partly in the Zendic or sacred dialect, and partly in the vulgar Persian language, contain narratives of the miracles and revelations by which Zerdusht is said to have established his religious system—the theological doctrines and religious ceremonies taught by him and his followers—and metaphysical speculations on the nature of the human soul, the principles of good and evil, and the ultimate triumph of the former over the latter. These, as well as almost every other remaining fragment of ancient oriental literature, are chiefly poetical, and some are said to be exquisitely beautiful in their style of composition. They also contain some excellent precepts of morality, and traditional records of former ages. From the general agreement of these traditional records and moral maxims with the facts and precepts of the Old Testament Scriptures, some have inferred that these Persian MSS. are of much later origin than the period usually assigned to them; whilst others have gathered from these ancient documents collateral and independent proofs of the authenticity and antiquity of the Jewish Scriptures. It may be added, in concluding this brief sketch of the literature of ancient Persia, that proofs are not wanting of the successful cultivation of the kindred arts of music, painting, and sculpture by Persian artists, some of whose names have been preserved, though their works have long since perished beyond all hope of recovery.—Vid. *Ancient Univ. Hist. (Persia.)*

SECTION V.

ARABIA.

43. THE records of antiquity furnish so little authentic information respecting the primitive history of Arabia, that it might not improperly be passed over without even a cursory notice in this review of ancient literature. There are, however, some circumstances that render an inquiry into the origin and progress of knowledge among the scattered Arab tribes peculiarly interesting, and which naturally prompt the wish, that the few fragments of history which yet remain on this subject should be preserved. One of the circumstances alluded to, is, their supposed descent from Abraham, the venerable Hebrew patriarch, by the line of Ishmael; from whom they may be supposed to have derived the knowledge, if not of the elements of philosophy and science, yet of subjects infinitely

more important—the one living and true God, and the homage and obedience due to him from all his intelligent creation. This knowledge, which could not but have been possessed by all the posterity of Abraham, was, alas! too quickly corrupted by his degenerate offspring who settled in Arabia; and who very soon fell into the common and fatal superstition of adoring the sun and moon and stars, erected temples and altars in honour of these luminaries, and invented symbolical representations of these gods of their idolatry. But though the worship of the celestial bodies characterized the religion of the vulgar, there is ground to believe that "the religion of the poets was pure. Theism; since there are Arabian verses of unsuspected antiquity, which contain pious and elevated sentiments on the goodness and justice, the power and omnipresence of ALLAH, or THE GOD. If an inscription said to have been found on marble in Yemen (the ancient name of Arabia) be authentic, the primitive inhabitants of that country long preserved the religion of their patriarchal ancestor, and professed a belief in miracles and in a future state."—*Sir W. Jones's Works,* Vol. I.

44. The interest excited by the circumstances just stated, is heightened by the fact of the preservation, in the Old Testament Scriptures, of an exquisitely beautiful historical poem of high antiquity—the scene of which is laid in Arabia—the principal personages introduced as taking part in the dialogue, are believed to have been Arabians,—and its author (if written by him, a part of whose

history it records,) was probably a Hebrew long resident in that country, who flourished during the patriarchal age. None can read with attention the book of Job, especially in its original dialect, and believe it to be a fragment of patriarchal history, written under the sanction of divine inspiration—whether by Job himself, or by the author of the Pentateuch—without being solicitous to know all that can be known of the country to which it relates, and the people whose manners it pourtrays—of the attainments then made in various sciences, and above all, the knowledge possessed by them of the "one living and true God." Another circumstance, which gives an unwonted interest to the question relative to the dawn of literature in Arabia, is, that in subsequent ages, Europe was greatly indebted to Arabic scholars for the preservation of some valuable relics of antiquity, and a partial revival of letters, when they had fallen into a lamentable state of decay. It will appear, from facts to be hereafter stated, that from Arabia emanated those rays of science which shed a transient gleam over the darkness of the middle ages. In the absence of well-attested historical facts, we can only have recourse to inferential reasonings, which warrant the conclusion that the attainments of these scattered pastoral tribes in civilization and general knowledge were by no means inconsiderable.

45. The following are the principal grounds on which this conclusion rests: — 1. Their contiguity to the Egyptians, and known intercourse with them, in very remote ages. Since it is well known that

in Egypt the arts and sciences were early cultivated, and made greater progress than in perhaps any other province of the East, it is reasonable to suppose, that a people bordering on that country, and intimately associated with them, partook in some degree of their illumination. 2. The introduction and prevalence of the Sabian religion furnishes another indirect proof; for though that system of religion was partly idolatrous, it was also speculative and metaphysical; and, wherever it spread, seems to have carried with it a taste for philosophical speculations. 3. A yet more conclusive argument in proof of the early civilization of the Arabians, is drawn from the antiquity, independence, and exquisite beauty of their language. Its *antiquity* is proved by inscriptions found on rocks, mountains, and decayed edifices in different parts of Arabia, the characters of which have become almost illegible by the lapse of ages, but which, as far as they can be decyphered, are found to contain ancient Arabic verses. Its *independence* may be inferred from the fact, stated by Sir W. Jones, that it bears not the least resemblance, either in words or in the structure of them, to the Sanscrit, which is the common parent of all the Indian dialects. And its singular *beauty* is asserted by the same learned author, who affirms, that "the Arabic, which is unquestionably one of the most ancient languages in the world, yields to none ever spoken by mortals in the number of its words and the precision of its phrases. 4. An additional evidence is found in the specimens of ancient poetry still extant in that language. The learned Schultens has preserved, in his "Ancient Memorials of Arabia," two elegiac poems, said to have been found about the middle of the seventh century, on some fragments of ruined edifices in Hadramût, near Aden, which are supposed to be of an indefinite but very remote age, and which, if genuine, are so regular in their construction, and so beautiful, as sufficiently to indicate the cultivated taste of their author. To the above may be added, 5. The architectural remains of Arabia, which, for whatever purpose the edifices may have been erected, could not have been built by a rude and barbarous people. From all these circumstances, it is concluded, that if "courtesy and urbanity—a love of poetry and eloquence—and the practice of exalted virtues, be a juster measure of perfect society, we have certain proof that the people of Arabia, both on plains and in cities,—in republican and monarchical states,—were eminently civilized for many ages before their conquest of Persia."*—*Sir W. Jones's Works,* Vol. I. p. 35—50.

46. On the same grounds, and by the same inferential reasonings, which render probable the early

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[*] Dr. J. Mason Good has stated, in the Preliminary Dissertation to his elegant version of the Book of Job (though on what ground the opinion rests, except that of the contents of the book itself, he has neglected to inform his readers), that "Arabia was perhaps earliest in possession of the most important arts and sciences, and especially those which relate to manufactures and commerce. It first cultivated poetry and eloquence with critical attention, and taught these refinements to Persia, as Persia afterwards taught them to the other parts of Asia."

civilization of the Arabians, their progress in moral and intellectual science may be conjectured. There is, however, in addition to these, an Arabian work of reputed antiquity, which (if really the production of remote ages) will prove, beyond doubt, that *ethics* were at least practically understood by them. The work now alluded to is, the "*Apologues of Lokmann,*" which has been long known to European scholars, through the imperfect medium of a Latin version, and which unquestionably contains much excellent moral instruction. From the resemblance which some of these fables bear to those of Esop, it has been concluded by some, that the Arabic Lokmann and the Grecian Esop were the same person; while others have contended, that the Arabian apologues were compiled in later ages from the Greek: but when it is remembered, that the most ancient mode of communicating moral instruction in the East was by parables or fables, and that the first principles of Grecian literature were of eastern origin, is it not more probable that those of Esop were borrowed from the Arabians? The celebrity of Lokmann, as a teacher of morality, may be inferred from the allusion to him in the Koran, where the Arabian Impostor introduces the Most High as saying, " We heretofore bestowed wisdom on Lokmann." He is supposed to have been contemporary with David; and if his origin were fabulous, it is not improbable that Solomon may have been the person intended.

SECTION VI.

EGYPT.

47. OF all the nations of antiquity, there is none whose pretensions to early civilization and improvement are higher than the Egyptians. They arrogated to themselves the honour of having been the preceptors of mankind. From them, as from the grand focus of science and learning, all those rays of knowledge were supposed to have diverged by which the rest of the world was illumined. Though truth will not permit us to concede all that is claimed by this people, it cannot be doubted, that in very remote ages, and when the far greater part of the human race was yet in a state of unlettered ignorance, the Egyptians had made great progress in the useful arts of life, and were not ignorant of the elements of science; nor can it be denied, that both Greece and Rome were greatly indebted to Egypt for instruction in various branches of knowledge. The Sacred Volume bears distinct testimony to their high reputation for learning, even as far back as the time of Moses; for that Hebrew legislator is said to have been "learned in all the wisdom of the Egyptians." From what source their knowledge was derived, and by what means this honourable distinction was attained, may be conjectured, but cannot now be ascertained with any degree of certainty.

48. Several circumstances have concurred to spread an unwonted degree of obscurity over the literary history of the ancient Egyptians, amongst which the following may be enumerated :—

1. The very remote period at which the dawn of philosophy commenced among them, stretching backward to an age anterior to the art of writing, when the most important knowledge could only be communicated by oral tradition, or rude symbolical inscriptions.

2. The cautious reserve with which their knowledge was concealed from the vulgar, by means of hieroglyphical characters, intelligible only to the priests, and the hidden meaning of which was eventually lost even by them.

3. The probable misrepresentations of the ancient Greek historians, who were prompted by national vanity to attribute to their own philosophers, speculations and inventions which were probably of Egyptian origin.

4. But most of all is this obscurity to be attributed to the utter destruction of the ancient records of Egyptian literature by the conflagration of the Alexandrian Library, which contained, it is more than probable, the works of Manetho, Cheremon, and other Egyptian writers, known to posterity only by name, or by a few scattered fragments of their writings. The loss of these ancient documents cannot be too deeply regretted, since they were the only sources from which authentic information could be obtained of the degree of science possessed by the earliest of the Egyptian Magi.

49. The ancients generally agree in tracing back the literature of the Egyptians, to the time in which an individual flourished, who bears a great variety of names. By the Egyptians themselves, he was called *Thoth*, and worshipped as a subordinate deity; by the Phœnicians, *Taaut;* by the Greeks, *Hermes;* and by the Romans, *Mercurius*. But who this far-famed personage was, or at what precise period he flourished, it were now vain to conjecture. Diodorus Siculus speaks of him, as "the prime minister of Osiris, one of their ancient kings, who improved language, invented letters, instituted religious rites, and taught astronomy, music, and other arts." This testimony is said to have been confirmed by the writings of Sanchoniatho, the Phœnician historian, and of Manetho, an Egyptian priest, who flourished in the reign of Ptolemy Philadelphus. The latter of the abovementioned authors mentions another *Thoth,* or *Hermes,* called also *Trismegistus,* who flourished long after the former, and by whom learning was revived after it had fallen into decay in that empire. By him, it is said, the hieroglyphical writings of the first *Hermes* were interpreted, the explanation of which, accompanied with large commentaries, were written in books, most sacredly deposited in the Egyptian temples, from which unhappily they never emerged. So extravagant are the fables respecting this supposed prodigy of learning, that he is said to have been "the author of more than twenty thousand volumes, which treated of universal principles, of the nature and order of celestial beings, of astrology, of medicine, and many other sciences."

50. The metaphysical philosophy of the ancient Egyptians, (or rather, of their priests; for to that privileged order all knowledge was confined,) bears a strong resemblance to that of the Hindoos and Persians, and probably had a common origin. It proceeded upon the principle of two original principles; the one material, passive, and inert; the other active, intelligent, and spiritual. The former of these was represented as *Chaos*, or *Night*, and worshipped under the name of Athor: the latter, according to Plutarch, was their supreme divinity, whose emanations filled the universe with light and life—with motion and enjoyment. But in connexion with this belief in an eternal, all-pervading intelligence, the Egyptians acknowledged and worshipped an immense multitude of inferior divinities, so that idolatry assumed amongst them its grossest and most loathsome form. Their notions of the human soul, of a future state of rewards and punishments, of the dissolution and reproduction of universal nature, with many other speculative tenets, were, it is highly probable, derived in the first instance from the family of Abraham, and were corrupted traditions of the original revelation. But with these were blended the mythological fables, that prevailed more or less among all the eastern nations, respecting transmigration, the state of the dead, and a thousand other speculative absurdities.

51. In common with all other oriental nations, the Egyptians directed their first attention to astronomy; a science, in the principles of which they were probably instructed by the Chaldæan

Magi. There is little reason to believe that their attainments in this sublime science were considerable. Indeed it is impossible, with the means of observation and knowledge then possessed, that they should have been such. Diogenes Laertius refers to astronomical calculations of eclipses made by the Egyptians, which carry us back to the sixteenth or seventeenth century before the Christian Æra. It has been inferred, from some passages found in the writings of Aristotle and Plutarch, that Pythagoras was instructed by the Egyptian priests in what is now known to be the true solar system, and that they maintained that the planets and comets revolve round the sun as their centre, and perform diurnal revolutions on their own axes; but if this knowledge were really possessed by them, it is manifest that this theory was treated by the Grecian astronomers as visionary and absurd, nor was it understood by the Egyptian priests themselves, who merely handed it down to posterity as an inscrutable mystery, to be believed, without evidence, on their sole authority. The more probable opinion on this subject is, that the Egyptian priests knew little more of astronomy than that which arose from an attentive observation of the aspect of the heavens, chiefly with a view to astrological predictions, or for the purposes of agriculture. Some practical skill, however, must have been possessed by this people in astronomical science when their Pyramids were built, since it is found that they are so constructed as exactly to face the four cardinal points, which could not have been effected without an accurate knowledge of the meridian line. All antiquity also attests, that the Egyptians first divided the year into twelve months, of thirty days, to which were afterwards added five supplementary days in every year, and a sixth every fourth year.

52. Geometry is universally acknowledged to have originated in Egypt. This is expressly asserted by Herodotus, the most ancient of profane historians, who gives the following account of the circumstances leading to the invention of this important science:—"I was informed," says Herodotus, "that Sesostris had divided Egypt among all his subjects, assigning to each an equal portion of land, on condition of paying an annual tax. If, in consequence of the overflowing of the Nile, the allotment of any one was diminished or rendered doubtful, the king caused it to be measured, and required a tribute in proportion to that which remained. "Hence," adds the historian, "arose geometry, and thus was it transmitted to the Greeks." But a modern writer on the history of this science has justly observed, that, though the statement of Herodotus proves some knowledge of geometry to have been possessed in the reign of Sesostris, the contemporary of Solomon, it does not prove that it originated at that time. The probability is, that it may be traced much higher; that the invention must have been prompted by the same necessity, which led to the use of the rule and square and compasses in architecture; and was practically, if not theoretically, understood in the very infancy of

society. There is no proof that the mathematical knowledge of the Egyptians exceeded that which was requisite to practise the art of mensuration, to construct drafts and schemes, the proportions and dimensions of which were accurately laid down; and perhaps, from these, by an easy transition, to proceed to the solution of a few simple geometrical problems.

53. The sciences of medicine and chemistry, in their most elementary states, have also been traced to the ancient Egyptians. The former of these, and its inseparable companion, anatomy, was certainly cultivated with some degree of success, at a very early period of the history of that nation. For the practice, observed by them from remote antiquity, of embalming the dead, proves their partial acquaintance with the properties of natural substances, the power of certain drugs in preserving from decay, and some degree of scientific skill in compounding them; and the manner in which this ancient rite was performed indicates some acquaintance with the construction and anatomy of the human frame. The invention of the healing art was ascribed by the Egyptians themselves to certain benevolent deities, to whom they gave the names of Isis and Serapis, or Æsculapius; and to whose honour they erected temples and altars: but it is probable that the true history of the case is, that these were individuals who rendered themselves eminent, while they lived, in the successful application of those drugs, with which Egypt abounds, to the cure of diseases, and

who, after their death, were elevated by their superstitious countrymen to the rank of demi-gods.

54. But the science (if science it may be called,) for which the ancient Egyptians were most famous, and which was most highly esteemed by them, was that of magic, or the power of producing supernatural appearances, interpreting dreams, and foretelling future events by certain mystical processes known only to the initiated. It cannot be doubted, that there was much of juggle and artifice in this pretended science—that the proficients in this art practised successfully on the ignorance and credulity of the vulgar; yet, from what is stated in the book of Exodus, of the successful imitation of some of the miracles of Moses by the magicians of Pharaoh, it is evident that they must have possessed a greater knowledge of some of the latent properties of natural substances than was known to their descendants, and that this their physical science was employed for purposes of deception. This art was founded on two principles of popular belief which then prevailed; the first, a persuasion that the heavenly bodies exerted a constant and mighty influence on mundane affairs; and the second, that spirits or dæmons of a nature superior to men were employed in the government of the world, and had their several provinces appointed them by the Supreme Divinity. In addition to the preceding facts, tending to prove the early civilization of the Egyptians, and their acquaintance with some of the practical sciences, it may be stated that commerce, if not invented by them, was much improved

and successfully cultivated in very remote ages; and that the art of navigation was carried farther by that ingenious people, than by any other of the oriental nations. — Vid. *Anc. Univ. Hist.* (*Egypt.*) *Enfield's Hist. of Philos.* Vol. I. p. 63.

SECTION VII.

PHŒNICIA.

55. PHŒNICIA was the connecting link between the eastern and southern provinces of Asia, and those parts of Europe and Africa which border on the Mediterranean. Its inhabitants are chiefly known to posterity as a commercial people. Their merchandize was extensive, and is said, in remote antiquity, to have reached even to the British isles. Together with the articles of commerce, to which they owed their wealth and political importance, they conveyed to other lands the knowledge, both scientific and practical, which they possessed. This knowledge was probably confined within narrow limits; but it was such as to render them eminently the benefactors of mankind. By the same process of inferential reasoning, which has been applied to Arabia, it may be concluded that the Phœnicians were not destitute of science. They must have possessed some geographical knowledge, accustomed as they were to make voyages to distant lands. They must have attained to no inconsiderable degree of practical skill in navigation, and as a prerequisite

to this, must have derived, either from the Egyptians or the Chaldæans, some knowledge of astronomy. Nor is it the least honour that attaches to this enterprising people, that while other eastern nations degraded the science of astronomy, by rendering it subservient to astrology, they applied it to the purposes of navigation. Fixing on one of the stars of Ursa Minor, situated near to that immoveable point in the heavens, called the North Pole, they were enabled to navigate the sea with greater certainty, and to undertake more adventurous voyages, than any other nation of antiquity. To these facts it may be added, that their merchandize could not have become so celebrated without some degree of physical science, by which they discovered the properties of natural substances, and some mechanical knowledge, by which those substances might be manufactured or otherwise prepared for exportation.

56. The principal reason, however, for including Phœnicia in this sketch of ancient literature is, that there appear to have flourished among that people two or three individuals who contributed, by their writings or their inventions, to the advancement and wider diffusion of knowledge. The most ancient of these was Sanchoniatho, whose history is involved in much obscurity, and whose writings are only known through the medium of other works of antiquity. If the testimony of Porphyry and Philo Biblius can be credited, Sanchoniatho flourished long before the Trojan War, and was a contemporary of Semiramis. But as these enemies of christianity evidently wished to throw discredit on the Jewish

Scriptures, by shewing that another history existed, giving a different account of the creation of the world than that given by Moses, and yet of equal if not greater antiquity, there is much reason to doubt whether reliance can be placed on their testimony. The principal evidence for the authenticity and antiquity of the works of Sanchoniatho, is Eusebius, a learned christian writer, who seems to have entertained no doubt of their genuineness, and has preserved some fragments of this ancient history, though he does not determine their date. In addition to the testimony of Eusebius, that of Theodoret may be mentioned, who informs us, that "Sanchoniatho wrote a history of the beginning of the world, with much fidelity, and applied himself diligently to the examination of ancient records; particularly those which contained authentic memorials of the Egyptian Taaut or Thoth, called by the Greeks Hermes, and by the Latins Mercury."

57. The cosmogony of Sanchoniatho, though a highly curious relic of antiquity, is too fanciful and absurd to obtain a place in the history of philosophy. Suffice it to say in general, that its distinguishing feature was, the notion that the material world was produced by the action or necessary energy of an eternal principle, destitute of intelligence and life, on an eternal passive chaotic mass. Such a system might well be denounced by Eusebius as direct atheism. It seems to have been of Indian origin, as a striking resemblance may be perceived between some of the speculations of the

Hindoo philosophers of antiquity, (as stated above) and the pretended history of the creation, given by the Phœnician historian. Here too we may perceive some of the rude chaotic elements, which were afterwards expanded into the Platonic philosophy. The most important use, however, to be made of this relic of antiquity, as far as it is now known, is to gather thence indirect evidences of the truth of scripture; for a modern writer has justly observed, "that we, who have in our hands the volume of divine revelation, may discover, even in this dungeon, many excellent relics of ancient traditions, which throw no feeble light on many passages of Holy Scripture; as they give us the origin and progress of that idolatry which was so long the opprobrium of human nature;" and, alas! is such still. They furnish, too, a complete confutation of the Chaldæan, Egyptian, Hindoo, and Chinese chronologies; proving, if they be genuine, that the world could not be older than it is said to be by Moses.

58. Some ancient writers speak of a Phœnician philosopher, (named *Moschus*, by *Posidonius;* and *Mochus*, by *Jamblichus*,) who is said to have flourished before the time of Pythagoras, but whom the learned Selden conjectures to have been no other than the Jewish legislator *Moses* himself. If any reliance can be placed on the testimony of the ancient writers mentioned above, *Moschus* was the founder of a system of philosophy, which afterwards became celebrated in Greece, as the *Atomic Philosophy*. Cudworth, in his elaborate researches into

the philosophy of the ancients, contained in his "Intellectual System," inclines to this opinion, and traces back what he terms the "*atomical physiology*," far above Democritus, or Epicurus, or even Pythagoras himself, to the Phœnician philosopher Moschus, who is said, by Strabo, to have lived before the Trojan War.—*Enfield's Hist. of Philos.* Vol. I. p. 58—62.

59. In even the most cursory sketch of ancient and modern literature, it were inexcusable wholly to pass unnoticed the individual who is generally believed to have communicated the knowledge of letters to the Greeks, and through them to the whole world. Whatever fables may have been interwoven with the history of *Cadmus*, there seems no reason to doubt that he was a native of Phœnicia, who introduced among the aboriginal inhabitants of that part of Greece in which he settled, the Phœnician alphabetical characters, which subsequently underwent gradual changes, till the Greek alphabet was produced. Humble as this attempt towards the civilization of a yet barbarous people may appear, the effects were incalculably great. It may be considered as the tender germ of that rich harvest of knowledge which has continued to be reaped from year to year, and from age to age, even to the present hour, and in almost every part of the civilized world.

PART II.

THE PHILOSOPHY OF THE GREEKS AND ROMANS.

CHAPTER I.

THE FABULOUS AGES.

60. WE now approach what may be justly accounted the chosen residence of Ancient Philosophy and Science; for whatever may be the claims of oriental nations to precedence in the order of time, it cannot be denied that Greece was the country in which literature of every description first acquired a regular and systematic form. The men of learning, who flourished at different and distant periods in Chaldæa, Persia, or Egypt, prepared the way, it is true, for the more celebrated philosophers of Greece; but it was not till the literature of the East was transplanted into the more fruitful soil of the Grecian republics, that the investigations and developements of human genius can be said to have acquired a permanent character. It is well known that Greece was first civilized by colonies from Egypt, Phœnicia, and Thrace. The

earliest institutions which prevailed, the most ancient dialects spoken, and the speculative opinions maintained, sufficiently indicate the source whence they were derived. It was therefore to be expected, that the resemblance would be strongly marked between the literature of the parent countries, and that introduced into the colonial settlements. Accordingly we find, that during what are usually, and not improperly, called *the fabulous ages* of Grecian history, the same mode of philosophizing was adopted, which had characterized the philosophy of the East, and the same sciences were cultivated in which some progress had been already made by their oriental instructors. The chiefs of the newly planted colonies, or those who had acquired the reputation of superior wisdom, taught the same religious dogmas, inculcated the same moral precepts, pursued the same intellectual speculations, and engaged in the same scientific pursuits, in which they had been trained from their earliest years by eastern Magi. As we have seen, in the preceding sketch of oriental literature, that the philosophers of India, China, Persia, Arabia, and Egypt, directed their chief attention to the origin of the material universe, its successive changes, and its final destination; or speculated on the nature of the human soul, its emanation, re-absorption, or transmigration; so the first subjects of investigation among the most ancient philosophers of Greece, seem to have been *Theogony* and *Cosmogony*—the nature of the gods and the formation of all things. These sublime mysteries, or rather, the absurd speculations of human ignorance respecting these mysterious subjects, were, after the manner of eastern nations, obscurely taught in allegories and mythological fables, disguised by poetical fictions the most extravagant, and, in some instances, most absurd.

61. From the scanty materials which the records of antiquity furnish of the infancy of Grecian philosophy, it may be gathered, that it was nurtured in the lap of the Muses; for, unquestionably, the first philosophers of Greece were poets. To their compositions we are indebted for all that is now known of the literary history of the fabulous ages. The most important sources of information on this subject, are the *Orphic Hymns*, and the *Poems of Hesiod;* for the traditions respecting Linus, as the inventor of lyric poetry, a skilful musician, and the writer of an ancient cosmogony, part of which has been preserved by Diogenes Laertius, are too vague and imperfect to claim a distinct notice.

Although it has been questioned by some among the ancients, and by many moderns, whether Orpheus were a real person or only a fictitious character, it is certain that there were verses commonly known in Greece at a very early period, bearing his name, and generally believed to have been collected after his death by some of his disciples. Diodorus Siculus speaks of Orpheus as a celebrated master of philosophy, poetry, and music, who acquired a knowledge of the mysteries of religion in Egypt, and taught them to his countrymen. The probable history of Orpheus is briefly this,—that he was one who acquired some distinction in a rude age, and amongst a comparatively uncivilized people, by his skill in music, poetry, astrology, and perhaps medicine also; that he thus acquired an ascendancy over them, so as to be held in high veneration by the barbarous tribes among whom he dwelt; and that this is the true meaning of the fable respecting the attractive influence of the lyre of Orpheus on the brute creation.

62. Fragments of the moral and philosophical poems attributed to Orpheus, have been preserved in the writings of Eusebius, Clemens Alexandrinus, Proclus, Apuleius, and others; from which may be collected some brief notices of the metaphysical theology of the remote age in which they were written. It will be manifest, from the following summary, that it was of eastern origin, and that it formed the basis of the several systems of philosophy which subsequently prevailed in Greece. From these ancient Hymns it would appear, that "the Orphic doctrines respecting God and nature were, that the supreme Divinity contained within himself, from all eternity, the unformed principles of the material world, and that he consisted of a compound nature, active and passive. By the energy of the active principle, he sent forth from himself, at the commencement of a certain finite period, all material and spiritual beings, which partake, in different degrees, of the divine nature. All beings, having emanated from the Deity, will, after certain purgations, return to him. The universe itself, after having been destroyed by fire, will be renewed, by

the power of Jupiter, in beauty and in perfection." Some critics have imagined, that the allegorical parts of these poems obscurely intimate the immortality of the soul, and a future state of rewards and punishments. Respecting the material system of the universe, he is said to have taught his disciples, "that the moon and planets are habitable worlds, and the stars fiery bodies like the sun, all of which are animated by subordinate divinities, who dwell in and preside over them."—*Enfield's Hist. of Philos.* Vol. I. p. 112—117.

63. The name of *Hesiod* next occurs in the annals of Grecian literature—if a collection of crude notions and absurd speculations respecting the genealogy of the heathen gods, and the origin of the material universe, may be permitted, on the ground of its antiquity, to claim this distinction. The general feature of Hesiod's system of theogony is, that "an eternal *chaos* was the origin of all things;" by which term he seems to have intended the elementary mass in which all the seeds of nature were contained, or that unformed matter, eternally existing, as a passive principle, whence all created forms have been produced. The basis of this system was evidently atheistical, though upon it was reared a massy fabric of superstitious theology.* The

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* Dr. Enfield has given, in the following passage, a luminous and correct view of these ancient systems, and pointed out their distinguishing features:—"There were different opinions among the ancient cosmogonists, concerning the first cause of nature. Some might possibly ascribe the origin of all things to a generating force destitute of thought, which they conceived to be

poems of Hesiod are no otherwise important in connexion with the history of Grecian philosophy, than as they contain the elements of some of those systems which afterwards acquired great celebrity, as affording the earliest indication of the dawn of Grecian literature, and as exhibiting a singular and deeply affecting example of the perversion of the human mind, without the aid of divine revelation. Homer, his illustrious contemporary, who recited those national ballads which were afterwards collected into the "Iliad" and "Odyssey," makes no pretensions to science or philosophy; but there is, in reality, more true wisdom, and a more intimate acquaintance discovered with nature—both animate and inanimate, corporeal and intellectual—in one page of the writings of that celebrated bard of antiquity, than will be found in all the didactic and mythological poems of Hesiod.

64. The next stage in the earliest history of Grecian philosophy, is that, in which poetical allegories gave place to *proverbial maxims*, delivered, with a kind of oracular dignity and authority, by a few individuals, celebrated for their political or moral

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inherent in matter, without looking to any higher principle. But it is probable, that the general opinion among them was that which had prevailed among the Egyptians and in the East, and was communicated by tradition to the Greeks, 'that matter or chaos existed eternally with God, and that by the divine energy of emanation, material forms were sent forth from him, and the visible world rose into existence.' This principle being admitted, the whole system of the ancient theogonies appears consistent, and a satisfactory explanation may be given of most of the Grecian fables."—Vid. *Hist. of Philos.* Vol. I. p. 121.

wisdom, and who were, on that account, emphatically styled σοφοι, or *wise men.* These were men of practical science, who, by their political institutions and moral precepts, contributed much more effectually and extensively to the improvement of society and the increase of knowledge, than all the speculative philosophers who had preceded them. The names of these distinguished individuals must be familiar to all who are conversant with ancient history; and many of their sententious aphorisms have been justly admired. Seven of these sages of antiquity obtained (whether by accident, or from their superior wisdom, it is not easy to determine) an honourable pre-eminence, which has rendered their names imperishable, though few memorials of their wisdom have been preserved. These were *Thales* of Miletus (to whom we shall have occasion to refer more particularly hereafter); *Solon,* the celebrated Athenian legislator; *Chilon,* a native of Lacedæmon; *Pittacus* of Mitylene, a city of Lesbos; *Bias* of Priene, in Ionia; *Cleobulus,* a Rhodian; and *Periander* of Corinth. Some writers substitute for the latter of these, the name of *Epimenides* of Crete, who flourished about the same period, and is said to have been the first builder of temples in Greece. Of the personal and private history of most of these individuals, little is known, (with the exception of Solon,) and that little is contradictory and uncertain. It is not, however, as princes, or statesmen, or warriors, they are introduced in this place, but as *ethical philosophers,* and teachers of moral wisdom, who employed their influence and talents for beneficial purposes. None of them (except Thales) were, in the strictest sense of the term, men of science; nor were they speculative philosophers, giving celebrity, like Plato or Aristotle, to theories of their own invention; but they did more—they brought their wisdom and experience to bear on the interests of social life, and the moral instruction of their species.

65. Without entering into detail, it may be sufficient to furnish a few specimens of the didactic aphorisms attributed to this class of ancient Greek philosophers.

(1.) To *Thales*, among many others, the following aphorisms are attributed: "Be equally mindful of friends, present and absent. Study not to beautify thy face, but thy mind. Enrich not thyself by unjust means. Cherish thy parents. If a governor, rule thyself. Use moderation. Believe not every thing. Be not idle, though rich." His favourite motto, attributed by some of the ancients to Apollo, was, *Know thyself*—a maxim which cannot be too deeply impressed upon the memory.

(2.) To *Solon*, among others of a political character, the following are ascribed:—"Nothing too much. Fly pleasures, for they bring sorrow. Observe honesty in conversation more strictly than an oath. Lie not, but speak the truth. Meditate on serious things. Procure not, nor part with friends, in haste. By learning to obey, you will know how to command."

(3.) To *Chilon*,—"Three things are difficult; to keep a secret, to bear an injury patiently, and to spend leisure time well. Visit your friend in adversity rather than in prosperity. Honour old age. Think before you speak. Gold is tried by the touchstone, and men are tried by gold:" to which some have added the above-mentioned motto of Thales, as first delivered by Chilon, "*Know thyself.*"

(4.) To *Pittacus*,—"Power discovers the man. Watch for opportunity. Reproach not the unhappy, for the hand of God is upon them. Whatever thou doest, do it well. What thou takest ill in thy neighbour, do not thyself."

(5.) To *Bias*,—"Great minds alone can support sudden reverses of fortune. Love your friend with caution, for hereafter he may become your enemy. Be slow in undertaking, but resolute in executing. Abhor to speak hastily, for then repentance follows. Preserve thy actions in remembrance."

(6.) To *Cleobulus*,—"Employ thyself in things excellent. Take care of thy body and soul. Govern thy tongue. Preserve piety. Do nothing by violence. Instruct thy children. If rich, be not exalted; if poor, be not cast down. Avoid excess."

(7.) To *Periander*,—"Pleasures are mortal, virtue is immortal. Seek to be worthy of your parents. There is nothing which prudence cannot accomplish. Keep thy word. Betray not secrets. Conceal thy misfortunes," &c. &c.

Such were the moral maxims delivered in the earliest period of Grecian civilization, which may be well supposed to have materially contributed to its advancement, by the ease with which they were remembered, and their adaptation to the circumstances of domestic and social life. Nor can we wonder that in the infancy of society, those who could express in a few words, and especially in verse, such useful moral precepts, should have become celebrated for their wisdom.*

CHAPTER II.

GENERAL CLASSIFICATION OF THE ANCIENT PHILOSOPHERS.

66. DURING the earliest period of Grecian literature, it will appear from the last chapter, that there flourished a few individuals, who were distinguished from the mass of their contemporaries by their reputed wisdom, and who exercised, while they lived, a kind of intellectual despotism over the understandings and opinions of the vulgar. Their maxims were deemed authoritative and oracular; their proverbial sayings were handed down from age to age with little less than religious veneration; and after their death, divine honours were, in some instances, paid to their memory. But none of these ancient sages appear to have gathered disciples around them, or reduced their philosophical specu-

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* Those who would extend the selection, will find them in an abridged form, in Dr. Enfield's History of Philosophy, and more fully stated in Stanley's Lives of the Philosophers. Their original terms have been preserved by Diogenes Laertius—Plutarch—Stobæus—and other ancient writers.

lations to a regular system. Satisfied with securing to themselves the reputation of wise men, they do not appear in any instance (if we except Thales of Miletus) to have aimed at the establishment of philosophical sects, bearing their name, and by which their tenets might be propagated. But in process of time, knowledge became more widely diffused among the Greeks, and assumed a more systematic character. Many engaged in the diligent pursuit of such speculative and practical sciences as were then imperfectly known, and attached themselves to different leaders. A species of literary oligarchy arose. It became an object of ambition to every candidate for literary distinction and posthumous fame, to become the founder of a new sect, and extend as widely as possible its distinguishing tenets. Hence arose the numerous schools of philosophy, which, for the most part, originated in Greece, or in some of its dependencies, and afterwards spread over the Roman empire and the greater part of the civilized world.

67. The principal schools of philosophy among the Greeks and Romans have usually been divided into two classes—the *Ionic* and the *Italic;* the former of which originated with Thales, and the latter with Pythagoras. From these arose numerous other sects, which were distinguished partly by the tenets they maintained, but chiefly by the individuals whose names they bear. Some of these were comparatively of short duration, but others long continued to flourish, and were propagated by many distinguished philosophers. From the inde-

pendent states of Greece, they were transplanted either into the metropolis of the Roman empire, or some of its distant provinces, until at length they were blended into one sect, which, from its amalgamation of different systems, was called the *Eclectic*, and which continued to flourish till the final subversion of the Roman empire. These ancient schools of philosophy were so various and numerous, and the philosophers belonging to each have been so frequently confounded, that it may not be unacceptable to the juvenile reader of these pages, to be furnished with a distinct classification of them, in the order in which they arose, that he may perceive at one view the sect to which they respectively belonged—the departments of physical or intellectual science in which they excelled—and the chronological order in which they flourished. For this purpose, the following Tables, though by no means complete, may perhaps be sufficiently accurate.

CLASS I.

SCIENTIFIC PHILOSOPHERS.

MATHEMATICIANS.	COUNTRY.	DATE.
Thales	Miletus	600
Pythagoras	Samos	550
Œnopidus	Chios	480
Zenodorus	——	*ibid.*
Democritus	Abdera	430
Hippocrates	Chios	450
Plato	Athens	370
Archytas	*ibid.*	*ibid.*
Leodamus	——	—
Thœetetus	——	—
Aristeus	——	380
Menechmus	Athens	*ibid.*
Dinostratus	*ibid.*	—
Eudoxus	Cnidos	365
Eudemus	——	—
Theophrastus	Lesbos	310
Isidorus	——	—
Hysicles	——	—
Euclid	Alexandria	300
Dinocrates	Macedon	*ibid.*
Nicomedes	——	280
Archimedes	Syracuse	250
Apollonius	Perga	200
Theodosius	Tripoli	60
Menelaus	Caria	A.D. 55
Diophantus	Alexandria	350
Pappus	*ibid.*	385
Diocles	*ibid.*	*ibid.*
Serenus	*ibid.*	380
Theon	*ibid.*	400
Hypatia	*ibid.*	*ibid.*
Proclus	Athens	460

ASTRONOMERS.	COUNTRY.	DATE.
Thales	——	—
Anaximander	Miletus	570
Pythagoras	——	—
Cleostratus	Tenedos	550
Philolaus	Crotona	400
Hicetas	Syracuse	—
Meton	Athens	440
Euctemon	*ibid.*	—
Calippus	Cyzicum	360
Eudoxus	Cnidos	—
Callisthenes	Macedon	330
Aristotle	Stagira	340
Eratosthenes	Alexandria	280
Timochares	*ibid.*	—
Aristillus	*ibid.*	270
Archimedes	Syracuse	250
Aratus	Tarsus	—
Aristarchus	Samos	280
Hipparchus	Nice	142
Posidonius	Rhodes	60
Cleomedes	——	70
Geminus	Rhodes	70
Sosigenes	Alexandria	35
Manilius	——	35
Frontinus	Rome	100
Ptolemy	Alexandria	140
Ctesibius	*ibid.*	*ibid.*
Hero	*ibid.*	*ibid.*
Anthemius	Tralles	*ibid.*

CLASS II.

PHILOSOPHERS OF THE IONIC SECT.

SCHOOLS OF PHILOSOPHY.	NAMES.	COUNTRY.	DATE.
Founded by Thales *of Miletus, about* A.C. 600.			
I. The Ionic (proper)	Anaximander	Miletus	
	Anaximenes	——	
	Anaxagoras	Clazomené	
	Diogenes Apolloniates	Miletus	
	Archelaus	Athens	
Founded by Socrates *of Athens, about* A.C. 420.			
II. The Socratic	Xenophon	Athens	
	Æschines	——	
	Cimon	——	
	Crito	——	
	Cebes	Thebes	
	Glaucon	Athens	
	Besides several Founders of New Schools.		
Founded by Aristippus *of Cyrene, in Africa, about* A.C. 380.			
III. The Cyrenaic	Arete	Cyrene	
	Antipater	Tarsus	
	Parabatis	Cyrene	
	Hegesias	——	
	Anacerris	——	
	Aristippus, Jun.	——	
	Theodorus	——	
	Bion	Borysthenes	
Founded by Euclid *of Megara, about* A.C. 360.			
IV. The Megaric, or Eristhic	Eubulides	Miletus	
	Diodorus	Caria	
	Stilpo	Megara	
	Alexinus	Elis	
	Euphantus	Olynthus	
	Apollonius (Cronus)	Cyrene	
Founded by Phædo *of Elis about* A.C. 360.			
V. The Eliac, or Eretriac	Plisthenes	Elis	
	Menedemus	Eretria	
	Æsclepiades	——	

SCHOOLS OF PHILOSOPHY.	NAMES.	COUNTRY.	DATE.
VI. The Academic,	*Founded by* Plato	*of Athens,*	*about* A.C. 370.
	Founded by Speusippus	*of Athens,*	A.C. 350.
Subdivided into 1. The Old Academy	Xenocrates	Chalcedon	
	Polemon	Athens	
	Crates	Ibid.	
	Crantor	Soli	
	(With several Founders of New Sects.)		
	Founded by Arcesilaus	*of Æolis*	*about* A.C. 280.
2. Middle Academy	Lacydes	Cyrene	
	Evander	Ibid.	
	Egesinus	Pergamos	
	Founded by Carneades	*of Cyrene,*	*about* A.C. 180.
3. The New Academy	Clitomachus	Carthage	
	Philo	Larissa	
	Antiochus	Ascalon	
	Founded by Aristotle	*of Stagira,*	*about* A.C. 350.
VII. The Peripatetic	Theophrastus	Eresium in Lesbos	
	Callisthenes	Olynthus	
	Strabo	Lampsacus	
	Lycon	Troas	
	Aristo	Coos	
	Critolaus	Athens	
	Diodorus	—	
	Demet. Phalerius	Athens	
	Dicearchus	Messenia	
	Eumenes	Rhodes	
	Founded by Antisthenes	*of Athens,*	*about* A.C. 380.
VIII. The Cynic	Diogenes	Sinope in Pontus	
	Onesicritus	Ægina	
	Crates	Thebes	
	Metrocles	Ibid.	
	Menippus	Sinope	
	Menedemus	Lampsacus	
	Founded by Zeno	*of Cyprus,*	*about* A.C. 300.
IX. The Stoic	Persæus	Corinth	
	Aristo	Chios	
	Herillus	Carthage	
	Sphærus	Borysthenes	
	Cleanthes	Lydia	
	Chrysippus	Solis in Cilicia	
	Zeno	Tarsus	
	Diogenes	Seleucia by Babylon	
	Panætius	Rhodes	
	Posidonius	Apamea in Syria	

Of the Ionic Sects, the schools which flourished most among the Romans were the *Academic*, the *Peripatetic*, and the *Stoic*.

CLASS III.—THE ITALIC SECT.

SCHOOLS OF PHILOSOPHY.	NAMES.	COUNTRY.	DATE.
	Founded by PYTHAGORAS *of Samos,*		A.C. 550.
I. The ITALIC (proper)	Aristæus	Crotona	
	Menisarchus	Samos	
	Alcmæon	Crotona	
	Empedocles	Agrigentum	
	Ecphantus	Syracuse	
	Hippo	Rhegium	
	Epicharmus	Coos	
	Archytas	Tarentum	
	Timæus	Locris	
	Philolaus	Crotona	
	Eudoxus, &c. &c.	Cnidos	
	Founded by XENOPHANES *of Colophon,*		A.C. 500.
II. The ELEATIC	Parmenides	Elea	
	Zeno	ibid.	
	Leucippus	ibid.	
	Melissus	Samos	
	Democritus	Abdera in Thrace	
	Protagoras	ibid.	
	Anaxarchus	ibid.	
	Founded by HERACLITUS *of Ephesus,*		A.C. 500.
III. The HERACLITEAN	Zeno	Athens (the Eleatic)	
	Hippocrates	Cos (afterwards Athens)	
	Cratylus	Athens	
	Founded by EPICURUS *of Athens,*		A.C. 300.
IV. The EPICUREAN	Metrodorus	Lampsacus	
	Polyænus	ibid.	
	Hermachus	Mitylene	
	Leontius	Lampsacus	
	Colotes	ibid.	
	Idomeneus	ibid.	
	Polystratus	——	
	Hippoclides	——	
	Basilides, &c. &c.	——	
	Founded by PYRRHO *of Elea,*		A.C. 320.
V. The SCEPTIC, or PYRRHONIC	Timon	Phliasia	
	Ptolemæus	Cyrene	
	Ænesidemus	Alexandria	
	Dioscorides	Cyprus	
	Menodotus	Nicomedia	
	Herodotus	Tarsus	

Of the Italic Sects, those which were best known, and continued longest to flourish among the Romans, were the *Pythagorean* and the *Epicurean*.

CLASS IV.

PHILOSOPHERS OF VARIOUS SECTS,

WHO FLOURISHED CHIEFLY UNDER THE ROMAN GOVERNMENT.

1. ACADEMICS.	2. STOICS.	3. PERIPATETICS.	4. EPICUREANS.	5. NEW PYTHAGOREANS.	6. CYNICS.	7. SCEPTICS.
Scipio Africanus	Q. Tubero	Tyrannio	Torquatus	Publius Nigidius	Musonius of Babylon	Zeuxippus
Polybius	Q. Luc. Balbus	Andronicus	Velleius	Anaxilaus	Demetrius of Corinth	Zeuxis
Lelius	Cato of Utica	Demetrius	Trebatius	Quintus Sextius	Œnomaus	Antiochus
Lucullus	Manilius	Crassus	Albutius	Sotion, Alexandrinus	Demonax	Sextus
Varro	Lucanus	M. Piso	Pansa	Moderatus	Crescens	Saturninus
M. Brutus	Persius	Sosigenes	Atticus	Apollonius Tyanæus	Peregrinus	Sextus Empiricus
Theomnestus	Athenodorus	Nicolaus	Virgilius	Secundus	Sallustius	
Cicero	An. Cornutus	Ægeus	Horatius	Nicomachus		
Thrasyllus	C. Musonius Rufus	Boethius	Lucretius			
Theon	Chæremon	Ammonius	Plinius Secundus			
Alcinous	Seneca	Aphrodiscus	Celsus			
Favorinus	Dion	Dexippus	Lucian			
Calvis. Taurus	Euphrates	Themistius	Diogenes Laertius §			
Apuleius	Epictetus	Olympiodorus				
Numenius	Sextus of Chæronœa	Simplicius, &c.‡				
Maximus Tyrius	M. Aurel. Antoninus					
Plutarch	Strabo					
Galen *	Apollonius †					

* The Platonic philosophers were eventually merged, and disappeared as a distinct sect, among the Eclectics.

† The Stoic sect gradually declined after the reign of the Antonines.

‡ Merged into the Eclectic sect, about the close of the second century.

§ Ibid.

CLASS V.

ECLECTIC PHILOSOPHERS,

OTHERWISE CALLED THE ALEXANDRIAN SECT, OR LATER PLATONISTS,

Flourished during the Second, Third, and Fourth Centuries.

◆

1. CHRISTIAN PHILOSOPHERS.

		A. D.
Justin Martyr	of Neapolis	150
Tatian	Syria	170
Theophilus	Antioch	180
Irenæus	Smyrna	*ib.*
Athenagoras	Athens	*ib.*
Pantœnus	Alexandria	*ib.*
Tertullian	Carthage	196
Clemens	Alexandria	200
Origen	Ibid	230
Anatolius	Ibid	270
Arnobius	Africa	285
Lactantius	——	310
Eusebius Pamph.	Cæsarea	327
Apollinarius	Laodicea	370
Gregory	Nazianzen	*ib.*
Gregory	Nyssa	*ib.*
Didymus	Alexandria	380
Jerome	Bethlehem	400
Chrysostom	Antioch	*ib.*
Augustine	Hippo	*ib.*
Synesius	Cyrene	410
Dionysius	——	420

2. PAGAN PHILOSOPHERS.

Potamo	Alexandria	180
Ammonius	Ibid	230
Dionysius Longin.	Emesa	260
Plotinus	Lycopolis	250
Amelius	Tuscany	260
Porphyry	Tyre	280
Jamblichus	Chalcis	340
Ædisius	Cappadocia	—
Eustathius	——	—
Eusebius	Myndus in Caria	327
Maximus	Nicomedia	—
Priscus	Thespotium	360
Chrysanthius	Sardis	—
Julian	Rom. Emp.	360
Eunapius	Sardis	385
Hierocles	Alexandria	400
Plutarch (Nest.)	Athens	420
Syrian	Alexandria	450
Marinus	Sichem	460
Isidorus	Gaza	500
Damascius	Syria	—

68. The preceding enumeration of the principal sects of Grecian, Roman, and Alexandrian philosophers, both scientific and speculative, may, it is presumed, be useful to the juvenile reader of the followng essays, by enabling him, as he proceeds, to determine the school of philosophy to which each of those individuals belonged, who will be more distinctly noticed hereafter; and by exhibiting, at one view, the ramifications of ancient philosophy, from when the scion was first transplanted from the East, to the period in which its sapless trunk mouldered into decay in its native soil. It would extend this historical review of ancient literature far beyond its assigned limits, and render the work extremely dry and uninteresting, were but a brief summary given of the distinguishing tenets of each sect, or of the systems advocated by the most celebrated of these ancient philosophers. Instead of this, the retrospect will be pursued in the following order.

I. The history of the abstract sciences, or ancient mathematics.

II. The history of physical science, both speculative and practical.

III. Ancient dialectics, or logic.

IV. Metaphysics, or pneumatology; and,

V. Ethics, or moral science.

CHAPTER III.

THE ABSTRACT SCIENCES.

SECT. I.

HISTORY OF MATHEMATICS,

From A.C. 640—300.

69. GEOMETRY is the only branch of mathematical science with which the ancients were acquainted, if we except a slight and imperfect knowledge of arithmetic, said to have been derived from the Phœnicians. It will be remembered, that, in the sketch of Egyptian literature, attempted in a former section, a reference was made to the origin of geometry in that country, and the circumstances were mentioned which first led to the study and practice of this important science. In its beginning it was considered but as a more convenient and accurate mode of mensuration than any previously known. Its practical utility therefore recommended it to the Egyptians, since it enabled them, with the utmost accuracy, to determine the rights of landed proprietors, after the annual inundation of the Nile had obliterated all traces of former occupation. Thence it was transferred to Greece, where it early assumed the form of an abstract science, and was cultivated far more successfully than in its native soil. Thales and Pythagoras, the celebrated

founders of the two principal sects of philosophy, are universally acknowledged to have been the first Grecian geometricians; but the degree of their mathematical knowledge, or the exact amount of their attainments in this department of science, it is by no means easy to determine. It is probable that many of the propositions found in the elementary works of later geometricians were first discovered by them, though others, by whom they have been preserved and transmitted to posterity, may have obtained the credit of their invention.

70. Thales, who flourished between A.C. 640 and 600, during his residence in Egypt, either taught the Egyptians, or, as is more probable, learned from them, the method of measuring the Pyramids of Memphis by the extent of their shadows. In either case, the fact proves some practical acquaintance with geometry. Several of the fundamental propositions subsequently incorporated into the Elements of Euclid have been attributed to him, particularly those in which it is proved that a "circle is bisected by its diameter; that the angles at the base of an isosceles triangle are equal; that vertical angles are equal; and that the angle in a semicircle is a right angle." These, though amongst the simplest theorems, were no inconsiderable discoveries in the infancy of mathematical science. All the ancient writers speak of him as a learned geometrician, and, among other important discoveries, ascribe to him the first employment of a circle for the measurement of angles.

Pythagoras, who flourished about half a century later, pushed forward the discoveries of Thales, and made more important discoveries. His name is rendered immortal among geometricians, by his well-known discovery, "that the square on the hypothenuse of a right-angled triangle is equal to the sum of the squares on the other two sides;" a discovery which is said to have occasioned such an ecstacy of joy, as to induce him to offer, as an expression of gratitude, an hecatomb to the gods. This problem is classed among the most important of geometrical truths, both from the singularity of its result, and the number of cases to which it may be applied in every department of mathematical science. To this philosopher belongs also the praise of having reduced geometry to a more regular system, by his demonstrations and inductive reasonings. Diogenes Laertius informs us, that it was he "who first abstracted geometry from matter, and elevated it from a scheme of mensuration to a truly philosophical science."

71. Next to the above-mentioned philosophers, the names of *Œnopidus, Zenodorus, Democritus,* and *Hippocrates,* occur in the list of ancient mathematicians. The former of these was a native of Chios, who flourished about A.C. 450, and of whom Plato speaks, as "one who obtained mathematical glory," though it is to be regretted that no traces of his works remain. Among the simple but important problems attributed to him, are those by which a perpendicular is let fall on a right line from a given point; an angle made equal to a given angle; and by which it is bisected. Of *Zenodorus,*

who was a contemporary of Œnopidus, more authentic information is possessed, since a portion of his geometrical writings has survived the wreck of ages, and is still preserved in Theon's Commentary. From these ancient remains, it may be gathered, that at the period in which this geometrician flourished, no inconsiderable progress had been made in that science. Among the services rendered by him to the abstract sciences, it was not the least that he corrected some false notions which had been previously entertained relative to comparative magnitudes, by proving that figures with equal circumferences have not necessarily equal areas. But of the philosophers enumerated above, HIPPOCRATES, who was also a native of Chios, and flourished about the same period, was by far the most distinguished. He is highly commended by Proclus as one who contributed greatly to the advancement of mathematical knowledge, and as having first compiled Elements of Geometry. About the period in which he flourished, the famous problem relative to the duplication of the cube engaged the attention of the geometricians, in consequence, it is said, of a response given by the Delphian Oracle, which, when it was inquired by the Athenians, how a dreadful pestilence, then raging at Athens, might be removed, replied, "*Double the altar.*" That altar being a perfect cube, it was proposed to the mathematicians of Greece to ascertain what was the precise quantity required. Hippocrates distinguished himself in this research, and seemed to have made some advances towards the solution of the problem; but geometrical knowledge was not then sufficiently advanced to enable him to surmount the difficulty, though he discovered some principles intimately connected with its solution, some of which still continue to bear his name.

72. The Platonic school, stimulated by the example, and aided by the discoveries of those who had preceded them in this department of science, greatly enlarged its boundaries. To Plato himself, or to some of his distinguished disciples, have been attributed the important discoveries by which an approximation may be made to the quadrature of the circle, the duplication of the cube, the trisection of angles, and (which is by far the most important of all) the method of *geometrical analysis*. A celebrated mathematician of modern times, whose competence to decide on the question, none, who are acquainted with his writings, can doubt, has given it as his opinion, that "the method of geometrical analysis constitutes the most valuable part of the ancient mathematics, inasmuch as a method of discovering truth is more valuable than the truths it has already discovered; and in another place, the same writer remarks, "the geometrical analysis, which is generally ascribed to the Platonic school, is one of the most beautiful and ingenious contrivances in the mathematics. It is a method of discovering truth, by reasoning concerning things unknown, or propositions merely supposed, as if the one were given and the other were really true. A quantity that is unknown, is only to be found by its relations to quantities that are known. By reasoning on these relations, we come at last to one so simple, that the thing sought is thereby determined. By this analytical process, therefore, the thing required is discovered, and we are at the same time put in possession of an instrument by which new truths may be found out; and which, when skill in using it has been acquired by practice, may be applied to an unlimited extent."* To Plato is also attributed the first invention of the four *conic sections;* previously no other species of curve had employed the speculations of men of science than the circle. This new and interesting branch of geometry, was diligently cultivated by his disciples, of whom Proclus enumerates twelve, who acquired considerable distinction, in an age in which knowledge was rapidly advancing. Among these were, *Leodamus,* who improved on the method of analysis; *Thœetetus,* who wrote Elements of Geometry; *Archiates,* who has the credit of having first applied the principles of geometry to practical purposes; *Aristeus,* who composed five books on the conic sections, highly applauded by the ancients, but which have not reached us; *Eudoxus* and *Menechmus,* who followed up, and more clearly demonstrated, the problem of doubling the cube, the properties of the conic sections, and many other propositions connected with what are termed *pure mathematics.*

73. Though Aristotle, the celebrated founder of the Peripatetic sect, does not chiefly owe his

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* Playfair's Dissert. ap. Encyc. Britt. New Supp. Vol. II. p. 3.

reputation to his knowledge of geometry, it is well known that no inconsiderable part of his voluminous writings relate to the abstract sciences. Blancanus, a learned commentator in Aristotle's works, collected an entire book of geometrical propositions, said to have been invented by this philosopher. Of his school, those who are known to have excelled in mathematics were, *Eudemus,* who wrote treatises on numbers, geometry and invisible lines; *Theophrastus,* who drew up a history of mathematics, part of which is still extant; *Isidorus, Hysicles,* and a few others, who chiefly directed their attention to the doctrine of solids, and thus opened a new field in geometrical science.

SECTION II.

HISTORY OF MATHEMATICS CONTINUED,

From A. C. 300 *to* A. D. 400.

74. THE muse of Poetry had attained her loftiest flights; Philosophy, her most refined speculations, and the Fine Arts their utmost perfection in Greece, long before the mathematical sciences had reached the meridian of their course. It was at a comparatively late period of Grecian history, that the most celebrated of her geometricians flourished. A firm and deep foundation had been laid, it is true, by Thales, Pythagoras, and Plato, and the superstructure was partly reared by the disciples of their several schools; but it was not till about the æra of

Alexander of Macedon, that the fabric of geometrical science was completed by the united labours of Euclid, Archimedes, and Apollonius,—names which unquestionably occupy the first place in the catalogue of ancient mathematicians. It is now impossible to ascertain what portion of the works of Euclid is original, or what was compiled from the writings of his predecessors. Posterity may therefore have awarded to him a meed of mathematical fame far beyond his just deserts. But, from whatever source his materials may have been derived, it is universally admitted, that the period in which the three abovementioned mathematicians flourished, is that in which geometry attained its maximum among the ancients, and from which it evidently began to decline.

75. EUCLID, the well-known author of the Elements of Geometry (who must be distinguished from the founder of the Megaric sect,) was of the Platonic school, and flourished about A. C. 300. The time and place of his birth are unknown; but it appears, from the Commentaries of Proclus, that he taught mathematics, and founded a geometrical school at Alexandria during the reign of the first Ptolemy, (or, as others affirm, of Ptolemy Philadelphus.) This is inferred from the well-known reply he is said to have given to that monarch, who enquired whether he could not teach him geometry by a simpler and easier process. "There is," said Euclid, "no royal road to geometry." This fact, attested both by Archimedes and Proclus, furnishes almost the only data from which to determine either the place

of his residence, or the æra in which he flourished. His chief merit seems to have consisted in reducing to order the scattered parts of the system of ancient mathematics, and in presenting the fundamental principles established by former geometricians in their natural order, adding to them others invented by himself. Professor Playfair, when adverting to the progress made by the Greeks in geometrical science, bears the following honourable testimony to the " author of the Elements." " The elementary truths were connected by Euclid, into one great chain, beginning from the axioms and extending to the five regular solids, the whole digested into such admirable order, and explained with such clearness and precision, that no similar work of superior excellence has appeared, even in the present advanced state of mathematical science."—*Playfair's Dissert. ap. Encyc. Brit. New Sup.* Vol. II. p. 3.

"No book of science," says a modern French writer, " has ever met with success equal to that of Euclid's Elements. They have continued to be taught exclusively in every mathematical school for many centuries; have been translated into almost all languages, and have been commented upon by numerous celebrated geometricians—a sure proof of their transcendent excellence."—*(Bossut's History of Mathematics.)* Besides this, his principal work, Euclid wrote several other mathematical treatises, some of which are still extant, though others, mentioned by Proclus, are lost.

76. Next in chronological order, but far superior in genius and science, stands the celebrated, the

unrivalled ARCHIMEDES. The scientific discoveries of this great philosopher will more properly claim our attention, when reviewing the history of Physics, or Natural Philosophy, among the Greeks. At present we shall only advert to him, as unquestionably the first of ancient mathematicians. He flourished at Syracuse about A. C. 250, and spent his whole life in the most unwearied and successful endeavours to promote the advancement of the sciences, both abstract and practical. "He assailed," says Playfair, "the most difficult problems in geometry, and by means of the *method of exhaustion*,* demonstrated many curious and important theorems with regard to the lengths and areas of curves, and the contents of solids." He was the first who discovered the relation between the circumference of a circle to its diameter, not indeed with geometrical strictness, (for this is found to baffle even modern science,) but by a method of approximation admirable in its kind, and which has served as a model for all subsequent investigations of a similar kind. His most celebrated work, (which fully proves the transcendent superiority of his genius to the proudest attainments of ordinary men, and renders him not unworthy of being placed by the side of the illustrious Newton,) is that on the dimensions and quadrature of the circle: besides which, he wrote (on mathematical subjects) treatises on the sphere and cylinder,—on spheroids and conoids,—of spiral lines,—of the quadrature of the parabola, &c. &c., irrespective of his works on natural philosophy, to be noticed hereafter. To the preceding summary of the geometrical labours of Archimedes, it may be added, that he extended and more clearly demonstrated the use of geometrical analysis, the principles of which were first discovered by the disciples of Plato. *Eratosthenes* and *Conon* were his contemporaries, either of whom would have acquired, in any other age, great celebrity in this department of science, but their fame was completely eclipsed by the dazzling lustre of the great philosopher of Syracuse. Archimedes requested, in his last moments, that a sphere inscribed in a cylinder might be engraved on his tomb, to perpetuate the memory of what he deemed his most glorious discovery. This was done, but the Sicilians so little honoured his memory, that the place of his sepulture was lost, till discovered by Cicero, when Quæstor of Sicily, by these symbols and a Greek inscription at their base, nearly two hundred years after his death.

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* This name was given by the ancients to that process of indirect demonstration, by which a great variety of difficult questions were solved relative to the limitation of figures inscribed on curves, or circumscribed round them, and the proportion of those limits to the areas of the curves with which they are connected. Professor Playfair, after having given a succinct but beautiful explanation of this branch of mathematics, adds, "Few things more ingenious than this method have been devised; and nothing could be more conclusive than the demonstrations resulting from it; but it laboured under two very considerable defects; viz. the long and difficult process by which those demonstrations were obtained, and its *indirect* form giving no insight into the principle on which the investigation was founded."---*Playf. Diss.* ut sup. pp. 6, 7.

77. Apollonius, a native of Perga, next occurs,

after an interval of about 50 years (A. C. 200,) in the series of ancient geometricians. As he is known to have studied and taught mathematics at Alexandria, it is not improbable that he continued the school founded in that city by Euclid. His contemporaries styled him, and not without reason, the *Great Geometrician,* an appellation confirmed by the suffrages of posterity, who place him next to Archimedes in mathematical attainments. He is known to have composed a great number of works on the higher branches of geometry, all of which have perished, except a few fragments and a Treatise, nearly entire, on the *Conic Sections.* This celebrated treatise was divided into eight books, the first four of which are still extant in Greek; the three next were only known by means of an Arabic translation and Latin version, effected during the middle ages, until translated into English by Dr. Halley, the astronomer, towards the beginning of the eighteenth century; and the eighth is entirely lost. On this work, Playfair remarks, that "his elaborate and profound researches on that species of curves, which, after the circle, are the most simple and important in geometry, laid the foundation of discoveries which were to illustrate very distant ages." Numerous have been the commentators on this celebrated work, both ancient and modern, of which the principal are, Eutocius of Ascalon, Pappus, and Commandine. Apollonius is believed by many to have been the author of those propositions contained in some editions of Euclid's Elements, and enumerated as the fourteenth and fifteenth books.

The age of Archimedes and Apollonius constituted the most brilliant æra in the history of ancient mathematics. After these great men disappeared, we meet with no geometricians of the first order, and scarcely any that can be considered even second-rate mathematicians. A few, however, may be cursorily mentioned as having contributed in some degree, if not to the advancement, yet at least to the preservation of geometrical science, though it will be seen that they appeared but at distant intervals.

78. Theodosius, who flourished about A. C. 60, is known as the author of a Treatise on *Spherics*, which may be considered as having prepared the way for the discovery of *spherical trigonometry;* none of the former geometricians having proceeded beyond plane trigonometry, or the measurement of heights and distances, by the sides and angles of a triangle. The Demonstrations of Theodosius are said to have been expressed with the utmost accuracy and elegance. *Menelaus*, who flourished about A. D. 55, pursued the same track, and, following up the principles of his predecessor, made considerable progress in spherical trigonometry. His work on *Spherical Triangles* is said to have been a laborious and learned performance, which contributed to the advancement of astronomical science. After a long interval of more than 300 years, we arrive at the æra of Pappus and Diocles, both of whom flourished about A. D. 385. Pappus is chiefly known as an industrious and valuable commentator on the works of those who had preceded him. "The mathema-

tical collections of Pappus," says M. Bossut, in his History of Mathematics, " exhibit one of the most valuable monuments of ancient geometry. In them, the author has assembled together a great number of excellent works, almost all of which are now lost; and to these he has added several new, curious, and learned propositions of his own invention. This collection, therefore, is not to be considered merely as a compilation, (though, in this respect, it is valuable,) since it gives us almost a complete view of the state of ancient mathematical science." *Diocles*, his contemporary, discovered a more original genius, if the statement be correct, that he succeeded in the solution of a problem suggested by Archimedes, in his Treatise on the Sphere and Cylinder, but left unanswered; a solution which is said to have been " most learned and profound." *Serenus* flourished about the same time, whose two books on the " Cylinder and Cone," Dr. Halley appended to his edition of the Conic Sections of Apollonius, and which are highly commended by that distinguished mathematician. The review of this period of the History of Geometry shall close with *Proclus*, who revived the Platonic school at Athens about A. D. 500; who rendered important service to the abstract sciences, not only by the effort he made to rekindle the languid and dying embers of philosophy, when almost extinguished in Greece, but still more by his valuable Commentary on the First Book of Euclid's Elements, from which the greater part of the preceding outline has been derived, and which will well repay the labour of a diligent perusal.

CHAPTER IV.

ANCIENT PHYSICS.

SECT. I.

ON THE ORIGIN AND PROGRESS OF ASTRONOMICAL SCIENCE IN GREECE,

From A. C. 640—300.

79. THE precise period in which astronomy was first introduced into Greece, cannot be fixed with any degree of certainty. Sir Isaac Newton traces it back to the Argonautic expedition, when he conceives the first rude sketch was made of the celestial globe, and some of the most remarkable luminaries were grouped together in constellations. Whether this opinion be well-founded or not, (and Newton was not given to theorize or take up opinions hastily,) it is certain that this sublime science had not approached towards a system, nor had any important discoveries been made, till Thales flourished, who may therefore be not improperly designated the father of Grecian astronomy. The knowledge which Thales had acquired in Chaldæa and Egypt, he extended by diligent study and attentive observation of the face of the heavens; and an impulse was given, by his instructions and example, to this science, the effects of which were apparent many ages after his death. Among the astronomical attainments of this philosopher, the following appear

to have been the principal. (1.) He ascertained and explained to his disciples the cause of the inequality of day and night—divided the earth into five zones by means of the polar and tropical circles—taught the obliquity of the ecliptic—and shewed that all the meridians which intersect each other at the poles, cut the equator at right angles. (2.) He is said to have observed the exact time of the solstices, and thus determined the length of the solar year, though not with scientific accuracy, yet so as to correct some prevailing errors in the calculation of time. (3.) He is said to have improved upon the Egyptian arrangement of the constellations, especially those which form the zodiac, combining a lively imagination with the love of science. Thales or some of his disciples embodied the stars in fabulous emblems, affixed to them names, borrowed from the popular mythology, and by this expedient rendered a subject, in itself dry and uninteresting, attractive even to the vulgar. The division of the zodiac into twelve constellations, which, if not invented, was completed by Thales or his immediate successor, has since obtained throughout Europe, and is still the only arrangement known to astronomers. (4.) Four of the planets were known to Thales, as they had been to the Egyptians, viz. Jupiter, Saturn, Mars, and Venus; and to these some have added Mercury, as first observed by astronomers of the Ionic school, though no accurate observations could have been made on their phænomena, at that remote period. (5.) But the astronomical fame of Thales was chiefly founded on his knowledge of the theory of eclipses, which had been for many ages the terror of the common people, and one of which (that happened during the war between the Medes and Lydians) he predicted some years before it occurred. This was of itself sufficient to render the philosopher of Miletus celebrated throughout Greece, and attract to his school numerous disciples. Among these, *Anaximander*, who flourished A. C. 600, ranks highest, in connexion with astronomy, as well as in metaphysical speculations. He is said to have set up a gnomon at Sparta, by means of which, time was more accurately measured, and the solstitial and equinoctial points were determined with greater precision. To him is also attributed the first invention of celestial globes and geographical maps, to the construction of which he was led by his conjecture, that the earth is spherical—a conjecture afterwards verified and demonstrated by Pythagoras.

80. While the philosophers of the Ionic sect were following up these investigations at Miletus, Pythagoras and his disciples were assiduously employed in Italy in similar pursuits, and met with still greater success. Of the discoveries of Pythagoras in this department of science, the following is a brief outline:

(1.) He proved, by physical observations combined with general reasonings, that the earth could not be, according to the popular belief, an extended plane, but must necessarily exhibit a curved and spheroidal superficies.

(2.) His opinions respecting the nature of the celestial bodies seem to have been, that the sun is an immense mass of fiery matter: that the moon is opaque, reflecting only the rays of the sun, and inhabited like our earth: that the galaxy consists of a great number of little stars of peculiar brightness: and that comets, which had before been regarded with terror, as fiery meteors, portending dire calamities, were a kind of wandering stars, disappearing in the remoter parts of their obits, and becoming visible as they approached the earth.

(3.) He is said also to have first discovered, that the evening and morning stars, called by the Greeks Vesperus and Phosphorus, were in reality the same planet, seen in different parts of its orbit, on the eastern or western side of the sun.

(4.) Perceiving the inaccuracy of former attempts to obtain a correct measurement of time, Pythagoras applied to this subject the whole force of his genius, and devised a method of reconciling, in some degree, lunar and solar time, by the expedient of intercalary days.

(5.) But the most remarkable fact in the history of ancient astronomy is, that the *true solar system* was either discovered by or known to Pythagoras, many centuries before it was generally received, and, which is perhaps yet more surprising, that after having been known and taught, it was universally abandoned as hypothetical and visionary. From the imperfect astronomical observations he was able to make, in the infancy of the science, this philosopher was led to the conclusion, that the sun is the centre of the planetary system, and that the earth and other planets move round this immense luminary at regular distances, and in certain harmonic proportions. So contrary, however, was this doctrine to vulgar prejudices, that neither Pythagoras nor his disciples ventured to teach it openly. It was communicated only to the initiated, and quickly forgotten, or renounced by the philosophers of his sect.

81. *Cleostratus*, an astronomer of the isle of Tenedos, and contemporary of Pythagoras, is chiefly known to posterity, by his attempts to correct the calendar, in which much ingenuity and no inconsiderable degree of science were discovered. About a century later, several astronomers directed their attention to the same difficult subject. These were *Philolaus*, a Pythagorean, who flourished A.C. 450, and is said to have openly asserted the then incredible fact, that the earth moves round the sun. *Hicetas*, a Syracusan, who taught the diurnal motion of the earth on its axis; and especially *Meton* and *Euctemon*, both of whom flourished at Athens about A.C. 440, and the former of whom is distinguished by the invention of the cycle of nineteen years, which still bears his name, being designated by chronologers, the *Metonic cycle*. Some defects having appeared after the lapse of a few years in the arrangement suggested by these Athenian astronomers, *Calippus*, another scientific Athenian, who flourished about A.C. 338, proposed a new cycle, which approached nearer to the correct division of time, though it was still far from being accurate. This was by connecting together four Metonic cycles, and forming them into one grand cycle of seventy-six years; at the close of which, one of the

intercalary days was to be retrenched. This is known to chronologers by the name of the *Calippic Period.*

82. Celebrated as is the Platonic school in the history of the Grecian philosophy, the science of astronomy was retarded, rather than advanced, by the speculations of Plato and his followers, as will appear from the following statement, made on no mean authority, and which it were easy to substantiate from the writings of the ancients. "The explanation of the celestial motions, which naturally occurred to those who began the study of the heavens, was, that the stars are so many luminous points fixed in the surface of a sphere, having the earth in its centre, and revolving on an axis passing through that centre in the space of twenty-four hours. When it was observed, that all the stars did not partake of this diurnal motion in the same degree, but that some were carried slowly towards the East, and that their paths estimated in that direction, after certain intervals of time, returned into themselves, it was believed that they were fixed in the surface of spheres, which revolved westward more slowly than the spheres of the fixed stars (as they are now called). These spheres must be transparent, or made of some crystalline substance; and hence arose the name of the *crystalline spheres*, given to them by the ancients. This system, though it grew more complicated in proportion to the number and variety of the phænomena observed, was the system of Aristotle and Eudoxus, and, with a few exceptions, of all the philosophers of antiquity." The name of Eudoxus has occurred in the preceding

extract (in which the opinions both of the Platonists and Peripatetics are clearly stated on the subject to which it relates), concerning whom it will be sufficient to state, that he was a Platonic philosopher, who built an observatory at Cnidos, the place of his birth, and wrote several treatises on astronomy, which have long since perished. He is also said to have first connected together the kindred sciences of geometry and astronomy, and understood, practically at least, the art of *dialling*, having himself constructed a sun-dial, which protected the shadow on a plane. Ancient writers notice the sphere of Eudoxus; but whether this was invented or only improved by this astronomer, is uncertain.

83. A new and vigorous impulse was given to that part of astronomical science which relates to the measurement of the earth's circumference by the splendid conquests of Alexander of Macedon, A. C. 330. The ambition of that monarch prompted him to aim at universal empire; and that he might form a distinct conception of the work before him, and the extent of his anticipated dominions, he called in the aid of science, to ascertain the true magnitude of the earth. This object, it was perceived, could be effected most easily and accurately by astronomy; that is, by attentively observing the position of the stars with relation to certain well-known terrestrial objects. The treatises of Aristotle, "De Cœlo," and "De Mundo," were partly written with this design; and Callisthenes, who flourished at the same period, was expressly commanded by Alexander to execute this arduous task. According to the rude calcula-

tions then made, Aristotle informs us, that the mathematicians, who had attempted to determine the magnitude of the earth's circumference, had calculated the amount to be 400,000 stadia. The first, however, of the ancients, who attempted the measurement of the earth on scientific and mathematical principles, was *Eratosthenes*, the librarian of the splendid collection of books then recently formed at Alexandria, and who flourished about A. C. 280.* To the same scientific philosopher is also attributed the invention and construction of an ingenious and useful instrument or machine, bearing some resemblance to the armillary sphere, which exhibited the relations of the meridian to the equatorial and ecliptic lines, and thus indicated the solstitial and equinoctial colures.

SECT. II.

THE HISTORY OF ASTRONOMY CONTINUED,

From A. C. 300 *to* A. D. 400.

84. AFTER the death of Alexander, and the consequent division of the Macedonian empire, the men of science principally resided at Alexandria in Egypt, attracted thither by the splendid patronage

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* A particular account of the method pursued by this mathematician and astronomer for the attainment of his object, and its results, is given by Cleomedes in his Cyclical Theorems, and will be found in a perspicuous abridged form, in Bossut's History of Mathematics, p. 108—111.

of Ptolemy Philadelphus, and the facilities afforded by the munificence of that monarch to the cultivation of knowledge. *Timocharis* and *Aristillus*, who flourished at Alexandria between A. C. 290 and 270, conferred important benefits on the science of astronomy, by making an immense number of observations on the relative positions of the stars, and on the motions of the planets; noting down, with the utmost exactness, the time when those phænomena appeared which attracted their notice. These observations were extremely useful to their successors, and formed, after the lapse of many ages, a basis for the more extended observations of Ptolemy. About the same time, an attempt was made to connect this science with literature and taste, by *Aratus*, who flourished under Antiochus, and who, at the request of that prince, reduced the principles of astronomy, as far as they were then known, to verse, in a poem entitled *Phænomena*, which was translated into Latin both by Cicero and Germanicus. But these attempts to advance astronomical science bear no comparison, in magnitude and importance, to the successful researches of Aristarchus and Hipparchus; names which unquestionably rank highest in the history of ancient astronomy.

85. ARISTARCHUS was a native of Samos, who flourished about A. C. 280. To this astronomer, posterity is indebted for several useful discoveries, and many highly important observations. Of these, the following is a brief summary:

(1.) He invented a simple, but scientific method of computing the distance of the sun and moon from the earth. His calculations, it is true, were wide of the truth, nor could they have been otherwise with the means of knowledge then possessed; but the attempt itself does honour to the memory of this celebrated astronomer, and still more the systematic manner in which that attempt was made on the principles of plane trigonometry.

(2.) Among other astronomical observations carefully noted by Aristarchus, one was a solstice, which happened, according to Ptolemy's calculations, A.C. 281, and by which we are enabled to determine the precise period in which this astronomer flourished.

(3.) To him, in conjunction with Eratosthenes, his companion and fellow-labourer, is ascribed the first successful application of mechanical science to the advancement of astronomy, by the construction of some rude but useful instruments, which Ptolemy has minutely described.

(4.) But a still higher honour is reflected on the name and memory of Aristarchus, by the well-attested fact, that he not only knew, but maintained and taught, the *true* SOLAR *system;* knowledge which he had probably derived from the Pythagorean school, but which neither the founder of that sect, nor his disciples, had the courage openly to assert. From the age of Aristarchus to that of Copernicus, including a series of more than eighteen centuries, this important truth lay concealed beneath a cumbrous mass of prejudice and superstition.

86. HIPPARCHUS (who occupies nearly the same place among astronomers, as Archimedes among the geometricians and natural philosophers of antiquity)

was a native of Nice, in Bithynia, and flourished about A.C. 142. He commenced his observations at Rhodes, but afterwards pursued them, with much greater advantage and success, at Alexandria. With unwearied industry, he continued to prosecute those labours, which not only reared a perennial monument to his own fame, but established his favourite science on a firm and permanent basis, which will probably endure to the end of time. As in the instances of those who preceded him, the most valuable results of these labours will be enumerated under distinct heads.

(1.) His first object was to correct the errors of former astronomers, with reference to the measurement of time, and determine the exact length of the solar year. Before his time, the year was made to consist of 365 days and six hours; this he found to exceed the true time, and, therefore, deducted seven minutes, which, though not perfectly accurate, was considerably nearer the truth.

(2.) Immense labour was bestowed by Hipparchus in the construction of *astronomical tables,* which explained the inequalities, or, as it was then termed, the *eccentricity* of the solar and lunar orbits, and determined their motions. With the modesty of a true philosopher, these calculations were announced as imperfect attempts, and a confident expectation expressed that, as science advanced, these problems would be more accurately solved.

(3.) A yet more important discovery (and one which proves the progress then made in astronomical science) is universally ascribed to Hipparchus;

namely, that of the *precession of the equinoxes,* or that retrogression which is observed in the equinoctial and solstitial points, with relation to the zodiac, or the fixed stars, and which is found, by the more accurate observations of modern science, to amount to fifty seconds in a year. This phænomenon, though imperfectly understood at the time of its discovery, has become of great importance in practical astronomy.

(4.) It is further attributed to Hipparchus, that he followed up successfully the design of Aristarchus, who had attempted to determine the ratio of the distances of the sun and moon from the earth, and that for his success he was chiefly indebted to the method he adopted of measuring by *parallaxes,* or the angle made by right lines from any star, or other celestial object, to the surface, and to the centre of the earth. His conclusions, it is true, were erroneous, but the method devised by him is still found eminently useful.

(5.) But the fame of Hipparchus, as an astronomer, chiefly rests on his attempt to number the stars, and assign to them appropriate names and relative positions. He was induced to undertake this herculean task, by the sudden disappearance of a new star, which had before attracted his notice. This remarkable phænomenon naturally prompted the desire to note down all the stars then visible, that posterity might know whether they were permanent bodies, or whether subject to changes. The execution of this bold attempt filled his contemporaries, and the men of science who succeeded him, with the utmost astonishment. "Hipparchus," says Pliny, in his Natural History, "has never been sufficiently admired, for no one has given proofs like him that man is allied to heaven, and his mind a portion of the Deity. He has even braved the anger of the gods, by making known to man the number of the stars, and has left the heavens, as an inheritance to those who may in future ages have sufficient skill to take possession of it."

87. After Hipparchus, no astronomer of high reputation and inventive genius appeared for several centuries. There were indeed not a few who profited by his indefatigable labours and science, so as to carry on his observations, and enrich the science with additional facts, or who more fully developed the theories which had been previously established. Among these, the following may claim a distinct notice:—

Posidonius, who flourished at Rhodes, about A. C. 60, and has been honoured with the appellation of *Geometer,* on account of his laborious attempt to measure the circumference of the globe. Cicero bears a high testimony to this astronomer, in his philosophical works, and especially adverts in terms of high commendation to his invention of a moveable sphere, the properties and construction of which are not known to posterity.

Cleomedes, who flourished about the commencement of the Christian Æra, and rendered an important service to astronomy, by embodying in a work, entitled "The Cyclical Theory of Meteors," all the discoveries of those who had preceded him in this department of science, from the æra of Thales to his own time. In this ancient treatise on astronomy, (the most ancient now extant,) most of the facts are contained, which have been stated in this and the preceding section, relative to the history of astronomy in Greece.

About the same time *Geminus* flourished, who is chiefly known as the author of "Elements of Astronomy," which contains not only the review of astronomical science among the Greeks, but carries the subject farther back, and treats of the astronomy of the Chaldæans and Egyptians in very remote ages.

The æra of Julius Cæsar is memorable as that of the reformation of the calendar on astronomical principles. It falls not within the design of this work to explain the nature of that reformation, nor is it now known by whose labours it was effected. Some writers have conjectured that it was chiefly, if not wholly, accomplished by *Sosigenes*, an astronomer whom Julius Cæsar brought from Athens to Rome.

Manilius wrote, during the reign of Augustus, a Latin poem, entitled *Astronomicon*—on the plan of the *Phænomenon* of Aratus. It is to be regretted that the science it contains, and the beautiful moral sentiments with which its pages are adorned, should be degraded by being found in connexion with all the mummeries and reveries of the Chaldæan astrologers. To add but one other to this list of second or third-rate astronomers, *Menelaus* (who has already been classed with the ancient geometricians, and who flourished about A. D. 50) contributed, in some degree, to the advancement of astronomy, by applying the principles of spherical trigonometry to determine the motions and distances of the heavenly bodies.

88. A considerable interval elapsed before another astronomer of eminence appeared in any part of the civilized world. During the Imperial government of Rome, poetry, sculpture, painting, oratory—all the ornamental arts and sciences, were cultivated, and attained a high degree of excellence; but the abstract sciences, amidst the luxuries of that degenerate age, languished, and gradually fell into decay. Before, however, their complete dissolution and abandonment, an attempt was made to revive them in the Alexandrian school of philosophy, by the celebrated PTOLEMY, whose name is identified with the whole system of ancient astronomy. It is not known whether Ptolemy was a native of Pelusium or of Alexandria, but he flourished during the reigns of Adrian and Antoninus, about A. D. 140. The celebrity of this astronomer is founded not so much on new and brilliant discoveries, (for in this respect he is far inferior to many who had preceded him,) as on his vast and almost incredible labours, his patience, perseverance, and unwearied industry in collecting and augmenting the stores of astronomical knowledge which had been accumulating in former ages. His principal work, entitled *Almagest*, (an Arabic word, denoting " the great Collection,") contains a digest of all the observations, discoveries, and opinions of former astronomers; to which his own researches being added, (which were by no

means inconsiderable,) the whole forms the most complete system of ancient astronomy that has ever appeared. The well-known theory of this astronomer relative to the solar system was, that the earth is fixed immoveably in the centre of the system, and that all the celestial luminaries revolve round it in their respective orbits. All the explanations given by him of the motions of the planets rest on this hypothesis, to which his authority as the first of astronomers insured an universal reception, and which still continues to bear his name, being usually designated the *Ptolemaic System.* The greatest difficulty with which Ptolemy had to contend was, to reconcile actual phænomena, of which he could not be ignorant, with this hypothesis; and for this purpose, he was under the necessity of framing theories and conjectures wholly unsubstantiated by evidence.

89. To the discoveries already mentioned, which were more fully demonstrated by Ptolemy, may be added some, the merit of which is exclusively his own, particularly those which relate to the inequality in the motion of the moon, known to modern astronomers by the term *evection;* a phænomenon which he both demonstrated and explained.* Following up the design of Hipparchus, he enlarged the catalogue of the fixed stars, and assigned distinct positions to no less than 1022; whilst he applied himself with no less diligence to the phænomena of the planets, calculating their distances, determining

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* See Playfair's Elements, Vol. II. pp. 129, 130.

their motions, and observing all their phænomena, as far as they could be discovered, by the means of observation then possessed. After Ptolemy, no astronomer is known to have flourished during the period under review, who can claim distinct notice, if we except *Theon,* author of a scientific commentary on Potolemy's "Almagest," and his renowned but unfortunate daughter *Hypatia,* who, after having presided with distinguished reputation over the astronomical and mathematical school of Alexandria, fell a victim to intolerance and superstition, in the disguise and under the name of Christian zeal.

SECTION III.

ON THE ORIGIN AND PROGRESS OF MECHANICAL SCIENCE.

90. THE practice of the mechanical arts was well understood by the ancients, long before the theory and general laws of that department of physical science were discovered. Necessity, the mother of inventions, prompted the Greeks at an early period of their history, as it had previously stimulated the Assyrians, Egyptians, and other oriental nations, to raise and transport large masses of matter and ponderous substances, by means not unlike those still in use: for without some such inventions, it would have been impossible to rear those massy fabrics, or to construct those splendid temples and forums, some of which are known to

have been erected from remote antiquity, and even the ruins of which are so magnificent. But it was not till a period much later than the known date of their erection, that the mechanical forces were theoretically understood, and mathematical reasonings employed to demonstrate their general principles and laws. Ctesiphon, for example, who is said to have built the celebrated temple of Diana at Ephesus, adopted the simplest and most strictly philosophical methods, by which to raise and fix the masses of stone employed in the construction of that far-famed edifice—in which were included the action of the lever and the inclined plane, and which implied a practical knowledge of the centre of gravity; but neither he nor any of the Grecian architects who succeeded him, down to the age of Archimedes, knew the *principles* of mechanical science, and still less were they capable of reducing them to a system. Even Aristotle himself, (who flourished as late as A. C. 320,) had most confused notions relative to the equilibrium and motion of heavenly bodies; and those who preceded him must necessarily have been still more destitute of science in these subjects.

91. The true theory of mechanical philosophy dates no higher than the æra of ARCHIMEDES. He is the first of the ancient philosophers who wrote systematically and scientifically on the principles and laws of mechanics. In his treatise on "Equilibria," he distinctly lays down, as the data of his mathematical reasonings, the general principles which modern science has fully established, relative to the lever, the balance, and the centre of gravity,

confirming those principles by facts which he had previously discovered by "*à priori*" reasonings. Thus was he led onward, by a yet untrodden track, to a great variety of important deductions, which were subsequently illustrated by experiment, and reduced to practice. How little progress had been previously made in this department of science may be inferred, from the astonishment which Hiero, king of Syracuse, and his courtiers, are said to have expressed, when that philosopher said, "Give me but a place on which to stand, and I will move the globe." This proposition, daring as it may appear to persons ignorant of the fundamental principles of mechanics, is, however, but a simple consequence of the well-known laws of equilibria, and the action of the lever. By the combined influence of mathematical and practical science, Archimedes demonstrated, that there exists in every assemblage of small bodies, and in every large mass of matter considered as such an assemblage, one general point of pressure, which moderns have termed the *centre of gravity*. Having established the fact, he proceeded to apply it to particular cases, and determined geometrically the precise situation of this centre of gravity in bodies of all shapes and dimensions, whether parallelograms, triangles, trapezia, or parabolas.

92. The mechanical inventions that are specifically attributed to this great mechanician are, the inclined plane, the pulley, and the screw: not, indeed, that no machines acting on these principles were ever before employed, but because he first

made known the theory, by which their powers and effects may be accurately determined. Combining these simple instruments in various forms, he produced machines of prodigious force, but of which little is now known except their names. Some of the ancients refer to the following, among other proofs of his mechanical skill. (1.) His construction of an engine by which to drain marshes and stagnant pools, or to empty the beds of rivers. (2.) Another machine, by which he launched Hiero's great ship. (3.) An engine, called trispaton, the nature and design of which is unknown, but to which Tzetzes refers, as a machine of immense power; and a variety of military engines, described by Plutarch, Polybius, and others, as employed with great effect during the memorable siege of Syracuse. To these inventions, Archimedes was chiefly indebted for the high reputation he enjoyed during his life, rather than to the science in which they originated. Had he satisfied himself with reasoning only on general principles, on the laws of matter and motion, or on the powers and phænomena of the equilibrium, however accurate and scientific those reasonings might have been, he would probably have sunk into an unhonoured grave, and his name had long since perished. Yet Archimedes does not appear himself to have set any high degree of value on these far-famed mechanical inventions. They were but the amusement of his leisure hours; in some instances, the mere sportings of his inventive genius. Plutarch, in his Life of Marcellus, informs us, that " Archimedes would not have carried so far his practical experiments, or diverted his attention so much from the abstract speculations, in which he most delighted, but for the pressing solicitations of Hiero, his royal patron and friend." The same writer has also added, in a strain of high but merited eulogium, (which is particularly deserving of notice, inasmuch as it exhibitis a comparative view of the estimation in which the speculative and practical sciences were held by the ancients,) " Archimedes was possessed of such a depth of understanding, such an elevation of sentiment, and so copious a fund of mathematical knowledge, that, though by the invention of his machines, he gained the reputation of a person endowed almost with divine knowledge; yet he did not vouchsafe to leave any account of them in writing: for he considered all attention to mechanics, and every art which ministers merely to common uses, as mean and sordid, and placed his whole delight in those intellectual speculations, which have an intrinsic excellence, arising from truth and demonstration only."---*Plut. in Vit. Marcell.*

93. The researches and discoveries of the philosopher of Syracuse were almost exclusively directed to that branch of mechanics to which the name of *Statics* has been given in modern times, and it must be admitted that in this he was eminently successful; but that elementary division of the science, which the moderns distinguish by the term *Dynamics*,* and

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* The term Dynamics has been, of late years, applied to that branch of physics which relates to the general laws of matter and

which develops the theory and laws of motion in general, was in a great degree unknown to the ancients. The notions formed by the most celebrated of the philosophers of antiquity on this subject, were extremely vague and confused. Aristotle, for example, has defined motion thus;—" the act of a being, in power as far as in power;" words to which it is impossible that any distinct idea should ever have been annexed: and though some may have conceived more clearly of its nature, its properties and laws lay far beyond the boundaries of ancient science. A few simple truths appear, indeed, to have been discovered by them relative to uniform motion, as that " the greater the space through which a body passes in a given time, the greater must be its velocity—that the ratio of its velocity is expressed by the proportion between the spaces passed through to the measures of time, or, in other words, that the spaces passed through are as the product of the times by the velocities; so that if the times be equal, the spaces are as the velocities, or the velocity equal, the spaces are as the times." But these almost self-evident truths can scarcely be dignified with the name of science; dynamics, there-

motion, or the doctrine of moving forces. Its proper business is to establish and demonstrate, by mathematical reasonings, the general principles applicable to all bodies in a state of motion, whether that motion be uniform, accelerated or retarded. Abstracting entirely from matter its accidental properties of figure, colour, hardness, &c., it contemplates alone the power, force, or action by which it is moved, the degree and direction of its motion, and all other phænomena resulting from its change of place.

fore, considered as a branch of mechanical science, must be reckoned among the results of modern science, though some of the general principles on which it is founded were manifestly known to Archimedes, and some other ancient philosophers.

94. It might have been reasonably anticipated, that the brilliant discoveries and high reputation of Archimedes, would have given a new and vigorous impulse to the science in which he so greatly excelled; and that, after his death, many would have been found who, guided by the torch of his genius, and stimulated by his success, would have made new discoveries, and carried forward his magnificent designs. But this was far from being the case. The science of *Statics* may be truly said to have been stationary after his death, or rather to have retrograded during many ages. Some few there were, who followed in the train of their great master, and gathered up those fragments of science, which fell from his hands, or escaped his notice—but no advances were made. Among the later proficients in mechanical science were *Ctesibius* and *Hero,* two scientific philosophers of the Alexandrian school, (who will be mentioned in connexion with another department of Physics, and who are said first to have applied the term, "*Mechanical Powers,*" specifically to the five simple machines, which still continue to bear that name); *Anthemius* of Tralles, and *Pappus* of Alexandria, each of whom successfully applied their extensive mathematical knowledge to the advancement of natural philosophy.

SECTION IV.

ON THE ORIGIN AND PROGRESS OF HYDRODYNAMICS.

95. BEFORE we proceed to the statement of facts connected with the subject of this section, it may be proper to premise, that the division of natural philosophy which it is intended to embrace, has been designated by the moderns *Hydrodynamics*, because its object is to apply the principles of the science of dynamics to that fluid with which we are most familiar, and explain the phænomena of water, both in a state of rest and of motion. The former class of phænomena constitutes the science of *Hydrostatics*, and the latter of *Hydraulics* ; the two great branches into which the science of hydrodynamics has been divided. As some progress was made by the ancients in each of these departments of physical science, it is intended to comprehend both in the present brief review. Solid bodies are more easily subjected to experiment and minute observation than fluid; and, consequently, it was much more practicable in ancient times, with the rude and imperfect instruments then possessed, to investigate the properties and laws of matter, in a state of solidity and cohesion, or as collected together in large masses; yet it will appear, from the following statement, that the properties and action of fluid bodies were not wholly disregarded.

96. The same great geometer and mechanician, who has been repeatedly mentioned in the preceding

essays, as occupying the first place among the practical philosophers of antiquity, was the first who discovered the fundamental laws of hydrostatics. A treatise of Archimedes has reached us, not indeed in its original form, but through the imperfect medium of an Arabic and Latin version, which treats of the *moleculæ*, or minute particles of fluid substances, their density, their equal pressure in every direction, and the principles on which the equilibrium of solids floating on the surface of fluids is preserved. The theory which he endeavours to establish by general reasonings and mathematical science, has since been fully confirmed by experiment. Amidst his researches on this subject, " he discovered," says Playfair, " the law which determines the loss of weight sustained by a body on its immersion in any fluid." His demonstration of this law rests on a principle which he lays down as a postulatum; viz. that in water, the parts which are less pressed are always ready to yield in any direction to those that are more pressed; and from this, by the application of mathematical reasoning, the whole theory of floating bodies is derived. The above is the same principle on which the modern writers on hydrostatics proceed; they give it, however, not as a postulatum, but as constituting the definition of a fluid.

97. The most remarkable experiment in hydrostatics which ancient history records, is that by which Archimedes detected the alloy of silver in Hiero's golden crown. That prince, having suspected the honesty of the goldsmith employed to

make him a new crown, applied to his scientific friend and subject to detect the fraud. Archimedes was at first unable to devise any means by which the desired problem might be solved; but at length, we are told, that the true method occurred to him while sitting in a public bath, and that he was so delighted with the discovery as to run home through the streets of the city of Syracuse, naked as he was, and exclaiming as he went, in an ecstacy of joy, "*I have found it, I have found it.*" The principle, to the discovery of which he was indebted for the solution of the royal problem, was the well-known theorem, "that two bodies, equal in bulk, and immersed in a fluid lighter than themselves, lose equal quantities of their weight;" or inversely, "that if two bodies thus immersed lose equal quantities of their weight, they are of equal volume." The use made of this general fact by Archimedes, and its application to the discovery of the specific gravity of bodies, will be readily found in almost all modern treatises on hydrostatics. At present, we have only to do with the interesting fact.

98. Among the mechanical inventions of Archimedes, was mentioned a machine for the drainage of marshes and rivers, which, on account of the use to which it was applied, may be considered as an hydraulic engine. This is supposed to have been an instrument similar to that which still bears the name of the screw of Archimedes,* and which has been found of great utility in raising water above

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* Encyc. Britt. art. *Hydrostat.*

its natural level. Diodorus Siculus asserts that he invented this machine during his travels in Egypt, and first employed it in that country to carry off more speedily the annual inundation of the Nile; but Vitruvius, and others, have questioned the originality of this invention, and maintained that, though much improved by Archimedes, the machine in question had been long known to the Egyptians, and employed for the purpose stated above. Without presuming to determine this litigated question, it may be affirmed, that, as far as the reputation of Archimedes is concerned, it is of little moment; for whether this be numbered among them or not, it may be affirmed, that "no individual, before the time of Newton, ever laid the foundation of more, or greater, or more important discoveries," fully justifying the eulogium which Wallis pronounced, when he styled him a man of prodigious sagacity, who laid the foundations of almost all the inventions which constitute the glory of the present age.

99. The next stage in the history of hydrodynamics, which can be distinctly traced, is that of the invention of pumps, syphons, and artificial fountains, for the elevation of water to considerable heights. These useful discoveries are attributed to the two mathematicians of the Alexandrian school, mentioned at the close of the last section, *Ctesibius* and *Hero*, both of whom flourished about A.C. 150. Ctesibius constructed a machine, in which the principle of the sucking and forcing pump was so combined and disposed, that, by their alternate action, the water

was drawn up and forced through a tube ascending between them. Hero, the pupil of Ctesibius, invented a fountain, which still bears his name, and produces its effect by the compression and condensation of air. But the inventors of these instruments, and those who continued to employ them for practical purposes, during many ages, were alike ignorant of the true cause to which their phænomena were to be attributed. The most visionary and unphilosophical theories were framed, by which to account for the elevation of the water after every stroke of the piston, among which, one was the celebrated Cartesian doctrine, that "nature abhors a vacuum." Nor was it till the æra of Galileo and Toricelli that the important fact was ascertained, on which the operation of hydraulic machinery chiefly depends.

100. In the absence of authentic historical information, it is only possible to conjecture when and by whom the ancient instruments, called *clepsydræ*, or *water clocks*, and *water mills* for the grinding of corn, were first invented. From the allusions made to both of these kinds of machinery by ancient writers, it may be inferred, that they were constructed in remote ages. The *clepsydræ* are attributed by Vitruvius to the Egyptians, or Persians, but it is not known on what authority. These were machines which measured time, and indicated the hour by the gradual rise of water flowing into a vessel in quantities regulated by the divisions of time, or, in other cases, by the movement of a hand, which the water turned by means of a wheel on which it was made to impinge with a duly regulated force.

These curious but uncertain machines, which Vitruvius has minutely described, were at length superseded by sand hour-glasses, acting on the same principle. From an epigram in the Greek Anthologia, it is concluded, that water mills were used for grinding corn in the reign of Augustus; but to the reproach of antiquity it must be stated, that no care was taken to preserve the name, or do honour to the memory of the individual, who rendered so valuable a service to his species.

101. In this, as in all other departments of physical science, it will be seen, that practice took the precedence of theory. Amidst all the improvements of art, and the splendid attainments of geometricians, the general principles on which the action of fluid bodies depend, whether in motion or at rest, were but imperfectly understood. The first of the ancients who appears from his writings to have formed any clear and definite notions of the general properties and laws of fluid bodies, was Sextus Julius Frontinus, who flourished under Nerva and Trajan, and to whom was confided the superintendence of the celebrated Roman aqueducts. In a practical and scientific treatise on these aqueducts, he states, as matters of conjecture, some theories relative to the motion of water in canals, and deduces from those supposed facts some general principles, which indicate no ordinary attainments in science. Many of these have since been verified and demonstrated, both theoretically and practically. Their author is, however, accused by the moderns of a want of geometrical precision in his scientific discoveries.

SECTION V.

ON THE PNEUMATIC DISCOVERIES OF THE ANCIENTS.

102. THE science of pneumatics embraces that division of physics, which develops the mechanical properties of air, and explains the phænomena which result from those properties. In proportion as air is a more subtile fluid than water, its phænomena may reasonably be supposed to have eluded the investigation of ancient philosophy. *Pneumatics*, therefore, considered as a science, must be reckoned amongst the exclusive attainments of modern times. Yet it is impossible that the acute and penetrating genius of the ancients should have wholly overlooked the element in which they breathed, and the atmosphere with which they were constantly surrounded. Ignorant as they were of its properties and laws, yet a thousand conjectures were framed, and innumerable speculations attempted on this subject, which are rather to be accounted the morning dreams of philosophy, than its sober and rational deductions. Thus, some of the Greek philosophers maintained, that "air was the first principle of all things, infinite and spiritual, without form or substance — a subtle æther, animated with a divine principle, which rendered it the origin of all created substances—that it is the Deity diffused through universal nature, and perpetually active," &c.

103. Such are said to have been the tenets of Thales, and the other philosophers of the Ionic

sect, derived unquestionably from the opinions of Eastern Magi. Others, as Plato and Aristotle, considered air as one of the primary elements of matter, which, combined with earth, fire, and water, constitutes and includes all the varieties of the material universe. These, however, though in themselves curious speculations, led to no valuable results, and are only deserving of notice as proofs of the error and delusion, to which the human mind is liable in its most diligent investigation, unless guided by the light of true philosophy, or the more infallible dictates of revealed truth.

104. The only department of pneumatic science, in which discoveries appear to have been actually made in remote ages, is that which relates to the theory of sound, to which modern science has given the name of *Acoustics*. This, though formerly considered as a distinct branch of natural philosophy, having been ascertained wholly to depend on the motion of air, is most properly classed, in the present day, with pneumatic experiments. The records of antiquity prove that this department of physical science was not wholly unknown to the ancients. The invention of different kinds of musical instruments, and the astonishing effects said to have been produced by ancient musicians, indicate a considerable advance towards perfection in an art which could not have been attained in any high degree without scientific knowledge. Pythagoras is universally acknowledged to have been the first among the Greeks, who applied the elements of arithmetical and geometrical science

to the theory of sound, and the laws by which it is propagated. To him is ascribed the invention of the *harmonic scale,* and the discovery, that *chords* are produced by *synchronous* or *isochronous* vibrations, that is, by vibrations measured by equal spaces of time; and *discords,* by those in which the spaces are unequal and various.

105. The manner in which that celebrated philosopher was led to this discovery has been thus stated by Nicomachus, an ancient writer on arithmetic: — "Pythagoras was passing one day by a blacksmith's shop, while several workmen were hammering on the anvil, and was surprised to hear sounds which accorded with the intervals of the fourth, fifth, and octave tones of the *diatonic scale.* On entering the workshop, he perceived that the diversity of sounds arose, not from the form of the hammers, or the force with which they struck the iron, but merely from the difference of their weight. Reflecting on the cause of this phænomenon, after he had caused the hammers to be accurately weighed, he concluded, that in exact proportion to the percussion was the vibration effected; and as these were in the gradation of four, five, and eight, the tones produced exactly corresponded with those proportions." If the testimony of this ancient writer is to be credited, such was the occasion, which led to the construction of the harmonic scale. But whether this be a fable or not, it is certain that to Pythagoras belongs the honour of having developed the musical ratios, on which the harmony of sounds depends, and to which the

ear is indebted for so much of its enjoyment. The lively imagination of this philosopher led him to transfer this doctrine of musical chords to the celestial spheres. He imagined that those spheres, in which the planets move, being composed of material substances, struck on the æther through which they passed, and thus produced sounds exquisitely harmonious; that these sounds must differ according to the magnitude, velocity, and relative distances of the bodies; and as these were admirably proportioned, they could not fail to produce perfect chords, infinitely diversified. This fanciful doctrine respecting what was then termed the *music of the spheres,* gave rise to the names affixed by Pythagoras to musical tones—the deepest or most grave being called after *Saturn,* because that body was believed to be the greatest and most remote of the planets; and the shrillest or most acute sound after the *Moon,* because the least of the planetary bodies, and nearest to the earth. These first ideas of Pythagoras relative to equal and unequal vibrations of air as the cause of harmonious or discordant sounds, were the true source of the theory and science of music; and the pneumatic discoveries of modern times have abundantly confirmed their truth.

SECTION VI.

ON THE OPTICAL DISCOVERIES OF THE ANCIENTS.

106. THE attention of men of science was directed at a very early period to the phænomena of vision,

and to the nature and properties of light. Many crude, unphilosophical, and even ridiculous notions were entertained on those subjects, even by the most celebrated of the Grecian philosophers. The question was frequently agitated by them, whether objects become visible by means of any thing proceeding from themselves, or of something that issues from the eye of the spectator. Pythagoras advocated the former of these positions, and contended that vision was caused by particles continually flying off from the surfaces of bodies, and entering the pupil of the eye. Plato, on the other hand, and some of his disciples, taught, that the gods having constructed the human eye, included in it a kind of fiery light, which, when the eye-lids are open, beams forth in rectilineal rays, and renders surrounding objects visible; but which, when the eye-lids are closed, acts internally, and occasions the illusions and fantasies of dreams. Aristotle, in opposition both to the Pythagoreans and Platonists, maintained that light is incorporeal; a quality of matter, and not a real substance; adducing, in proof of this position, many arguments derived from its transparency, velocity, and intangibility. Yet amidst these fanciful speculations, there was found among the Platonists a portion of true science; for they are said to have maintained that light is propagated alone in right lines, and that it is capable of being reflected in an angle, which is always equal to the angle of incidence. And the Peripatetic philosophers, with Aristotle at their head, are known to have ascertained some of the laws of reflection, and explained by them the phænomena of the rainbow, halos, parhelia, and the like—all of which the ancients comprehended under the general name of *meteors.* Aristotle's opinion concerning these was, that they are all occasioned by the reflection of the sun's beams in different circumstances, by which an imperfect image of his body was produced, the colour only being exhibited, and not his configuration.

107. Nor were the ancient philosophers wholly ignorant of the theory of refraction, though their methods of solving the problem were most erroneous and unsatisfactory. They could not but perceive the obvious fact, that when light passes through bodies of different densities, it does not move forwards in right lines, but is bent, or refracted out of its course. Aristotle suggests many questions on this as well as other optical appearances, and attempts to reply to them on philosophical principles; but his answers are most frivolous and absurd. It is to be regretted that a tract written by Archimedes, on the appearance of a ring or circle under water, has perished; since it is probable that the solution given by him was more scientific and rational, in proportion as his mathematical knowledge was greater, and his judgment more penetrating and profound. Some vague conceptions seem also to have been formed by Seneca, the Stoic philosopher, (who flourished at a much later period,) relative to the production of colours by refracted light; though he attributes those appearances not to any real difference of colour, but to the different direction in

which they are observed by the spectators, so that the same object will exhibit different colours to persons viewing it from different points.

108. The next important stage in the history of optical science was, the art of *constructing mirrors;* an art which can be traced to remote antiquity, though its inventor and the date of the discovery are alike unknown. These were at first made of metal, highly polished, in the several forms of plane, convex, and concave surfaces. But after the art of making glass was discovered, mirrors, constructed of this material, were substituted for the metallic. The following account is given by Pliny of the accident which led to this invention: "some merchants, who traded in mineral alkali, having occasion to dress their food, and being unable to find stones on which their culinary vessels might rest, placed them on large blocks of mineral alkali, which being melted by the heat of the fire, and mixing with the sand on the sea-shore, flowed, to the surprise of the merchants, in a translucent crystal stream; "whence," says Pliny, "originated the making of glass." To what period this fact refers, the historian does not inform us; but from other sources it may be gathered, that if such were the origin of the invention, it must have been in some very remote age: for the works of Aristophanes, (who flourished about A. C. 430,) confirmed by the testimonies of Diodorus Siculus, Plutarch, and others, prove that mirrors and lenses were early invented, both for the purpose of reflecting distant

objects, and collecting into a focus the solar rays.* *Plinii Hist. Nat.* lib. xxxvi. c. 26.

109. But the most astonishing proof of the progress made by the ancients in this department of science, may be gathered from the statements of Diodorus Siculus, Pappus of Alexandria, and others, respecting the lenses, or burning mirrors, with which Archimedes is said to have set on fire and destroyed the Roman fleet, at the siege of Syracuse. This achievement was in itself so marvellous, that we cannot be surprised at the attempts of scientific men in modern times to impeach its credibility. Among others, Descartes asserted, and attempted to prove, the utter impossibility of accomplishing what Archimedes is said to have done, even with all the aids and improvements of modern science. The historical fact, as stated by two ancient authorities, Zonaras and Tzetzes, is simply this; " that when Marcellus had removed his fleet beyond the reach of the enemies' darts, Archimedes brought to bear upon it a large hexagonal mirror, composed of several smaller mirrors, each of which had twenty-four angles, and which could be easily moved in any direction by hinges or plates of metal. The rays

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* Aristophanes, in his celebrated comedy of " the Clouds," ridicules Socrates by representing him as giving philosophical lessons to some obscure and unprincipled Athenians, and, among other proposals, one is, that the debtor should, by means of a reflecting mirror, melt the waxen tables, on which the records of his debts were inscribed :—A sufficient proof that, at that period, some such invention as that of burning lenses had been discovered.

of the sun falling on this mirror, kindled so great a fire, that the Roman vessels were quickly burnt to ashes, though at a greater distance than a dart could be thrown." The incredibility of the statement itself,—the silence of Plutarch, Polybius, and Livy on the subject, and the authority of Descartes and other celebrated moderns, so discredited the tale, that few men of science, who lived during the 17th century or later, were disposed to believe it. But, according to Bossut, in 1747, Buffon proved, by actual experiment, the practicability of such an achievement; and in 1777, a fragment was discovered written by Anthemius, who flourished under the Emperor Justinian, that places the question beyond all doubt. In that fragment (the genuineness of which was fully proved by Dupuy, its scientific translator,) Anthemius, himself a celebrated mechanician, not only asserts the disputed facts, but clearly explains the manner in which the mirrors were constructed, the several parts of which they were composed, and the entire mechanism employed on this occasion, by the Syracusan philosopher.

110. It is not a little remarkable, that with this practical knowledge of the method of manufacturing glass, and constructing reflecting mirrors of immense power, there should be no proof whatever, that perspective or magnifying glasses of any description were invented by ancient opticians. These might have been expected to result from the discoveries, with which they were familiar, but there are no authenticated evidences that any such

mechanical contrivances were devised. It has indeed been asserted (but on very questionable authority) that Ptolemy Philadelphus built a tower, or observatory, in the isle of Pharos, and that on the summit of that edifice were placed telescopes of great powers, by which vessels might be discerned at a distance of sixty miles. It is not, however, credible that this important discovery should have been made in Egypt, in the reign of Ptolemy Philadelphus, and yet be unknown to the Romans at a much later period, who annexed that province to the Roman empire, and brought to its capital most of the literary stores of Alexandria. From the "Quæstiones Naturales" of Seneca, it is evident that, in his time, the only kind of magnifying glasses in use were glass globes filled with water, used by artists in engraving transparent gems, or by antiquarians in decyphering illegible inscriptions. It is probable that the great obstacle which presented itself to the ancient mechanicians, and prevented them from constructing perspective glasses of any description, was, their ignorance of the method of grinding or cutting glass, so as to exhibit a convex or concave surface; the utmost extent of their science on this subject not having proceeded farther than to the manufacture of hollow glass vessels, globes, and mirrors, whose surface was horizontal.

111. A treatise on optics has been preserved, which tradition ascribes to Euclid, but the contents of which seem to indicate a later and much inferior hand. This treatise chiefly relates to the method

of determining the size and figure of objects, by the angle under which they appear, and the phænomena of reflected images in general. But the most scientific treatise on optics, written during the period under review, was that of Ptolemy the astronomer, in which he applied the laws of refraction, as far as they had then been discovered, to his favourite science, and thus discriminated between the real and apparent places of the heavenly bodies, as well as accounted for the greater apparent magnitude of the sun and moon, as they approach the horizon. This work, and its principal contents, are only known through the imperfect medium of later compilations and commentaries, the original having long since disappeared. After Ptolemy, nothing occurs to claim the attention of the historian in connexion with optics till the revival of that science in Arabia during the middle ages.*

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* On the subjects included in the preceding sketch of ancient physics, consult the histories of the several sciences referred to, particularly Montucla's History of Mathematics, Smith's History of Astronomy, and on Optics,—Playfair's Dissertation, Memoires de l'Academie de Belles Lettres, &c.

CHAPTER V.

ANCIENT DIALECTICS.

SECTION I.

ON THE ORIGIN OF LOGICAL SCIENCE.

112. IN tracing the progress of knowledge, it will be perceived, that its advancement has frequently been rather the result of necessity than of choice, and that the particular direction which it has taken arose from circumstances apparently accidental. Thus the arts, which were most conducive to the happiness of man, or ministered to his wants, were cultivated long before the regions of metaphysical speculation were explored: the properties and phænomena of matter were investigated before those of the human mind engaged the attention of philosophers. And when this latter department of philosophy began to flourish, it was pursued rather as an art, to be applied to useful purposes, than as an abstract and speculative science. The *dialectic* art, which proposed to instruct mankind in the right exercise of their intellectual powers, and professedly taught them to reason correctly, was rendered necessary by the state of philosophy in Greece, at the period in which it originated. The Ionic sect had spread itself in every direction, and several new schools of philosophy had arisen. Each of these

was characterized by its own tenets, which, in many cases, related to verbal rather than real distinctions. In proportion as these differences were trifling and unimportant, it became necessary that the reasoning powers of the advocates of different systems should be rendered acute by constant exercise, and that they should stand alike prepared for attack and defence. The founders, therefore, of these rival sects were compelled to employ their utmost ingenuity in maintaining and vindicating the systems which they had espoused, and assailing the strongholds of their adversaries.

113. The term *dialectics*, in its proper and definite acceptation, refers alone to that department of logic, which suggests rules for discussion; but the ancients used it with greater latitude of interpretation. By them it was understood to include all that relates to the improvement and exercise of the rational faculties. It not only taught the art of reasoning, but comprehended metaphysical inquiries into the nature and origin of ideas, the phænomena and laws of perception, and all the sources of human knowledge. On this account it is frequently difficult to draw the line of demarcation between the logic and metaphysics of the ancient philosophers; and it will be perceived, that in attempting to sketch the former, it is scarcely possible to avoid topics which more properly belong to the latter. The most ancient name given to that branch of science which moderns call *logic*, was *analytics*. It was so designated by Aristotle himself, in his own writings. But that of *dialectics* gradually came into use, on

account of the manner in which philosophers of different sects communicated their instructions. It was usual for the several masters to exercise the talents of their disciples in dialogues and debates, on which occasions, difficult questions were proposed and discussed, objections were started, and arguments suggested in reply; propositions were controverted or defended according to the rules of art; and he was accounted the most skilful dialectician, not who elicited truth, but who confounded and silenced his adversaries, whether by sophisms or sound arguments.

114. Such was the practice of that class of philosophers, termed *Sophists*, among whom the art of logic originated. The principal of these belonged to the Eleatic and Megaric sects; and on this account, *Zeno, the Eleatic*, has been generally considered the inventor of *dialectics*, because it was he who reduced to system and order the methods of reasoning which had been previously adopted in the schools. It is supposed that some of the technical rules suggested by Aristotle in his logical treatises, were either the invention of Zeno, or of some other Eleatic philosophers. Compared, however, with the systematic form which logic assumed under the plastic hand of the Stagirite, the dialectics of the Sophists were exceedingly imperfect, and consisted of little more than mere verbal disputations. By them, the faculty of reason was perverted from its important and legitimate object—the discovery of truth—to technical forms and modes of discussion favourable to the propagation of error

and falsehood. The most celebrated of these Sophists taught their pupils to argue with equal facility on either side of a question, and, if possible, to confound their opponents by the subtilty of their reasonings, rather than convince them by force of argument. The ingenuity and dexterity evinced in these dialectic contests, obtained for those who excelled in them, a high degree of celebrity: they were applauded in popular assemblies, entertained at public feasts, and sometimes enriched with the most valuable and costly presents. One of the philosophers of antiquity, however, by making his appeal to nature and truth, put to flight the whole host of Sophists, and rendered them objects of contempt and ridicule. This was SOCRATES, who, though not classed among the dialectic philosophers of antiquity, contributed more than any other to the introduction of a new and more useful species of logic. He effected this, partly by directing the attention of his disciples to subjects of higher interest and greater importance than those on which their intellectual strength had formerly been expended, and partly by introducing a more simple and natural mode of philosophizing. This method has been generally termed the *Socratic*, and consisted rather of questions and responses, or familiar dialogues, than of systematic discussions and controversies. The influence of this mode of communicating and receiving instruction, was sufficiently evident in the character and writings of Plato, and others of his illustrious disciples.

115. Before the proposed retrospect of ancient logic, which it is intended to introduce into this elementary work, is attempted, it may be useful to exhibit at one view a general classification of the principal dialectic philosophers of antiquity.

The following arrangement is perhaps sufficiently accurate, though the writer is conscious that it is far from being complete:

CLASS I.—The *Sophists*, including all the earliest Grecian philosophers of whatever sect, who directed their attention to the art of reasoning, from the æra of Thales to that of Socrates and Plato. This may be denominated the infancy and childhood of the dialectic art, during which, though some progress was made, yet every stage of that progress was characterized by puerilities and perverted talents.

CLASS II.—The *Academics*, including all those of the Platonic schools who excelled in dialectics, whether they belonged to the Old, or Middle, or New Academy. These were considerable in number, and include some of the most eminent men of antiquity, both Grecian and Roman.

CLASS III.—The *Peripatetics*, commencing with ARISTOTLE, who unquestionably holds the first place among the ancient dialecticians, and who established, by his oral instructions and writings, a species of intellectual despotism, from which the human mind is scarcely yet emancipated, after an interval of more than two thousand years.

CLASS IV.—The *Stoics*, who blended the rhetorical and dialectic arts, and included under the generic term *logic*, all kinds of metaphysical speculations, and all possible combinations of ideas and terms. The system of dialectic philosophy propagated by this far-famed sect, may be considered as compounded of the Megaric logic, or that of the Sophists; and the Platonic, but partaking in a much greater degree of the latter.

CLASS V.—The *Epicureans*, who, though they affected to decry logic as a frivolous exercise of the mental powers, and especially to despise the logic of Aristotle, yet retained the thing under a new name; for it will be seen that the *Canonica* of *Epicurus* differ but slightly from the dialectic rules previously suggested by the Peripatetics.

SECTION II.

ON THE DIALECTICS OF PLATO AND THE ACADEMICS.

116. THE brief notice of the Sophists, introduced into the last section, may suffice for a review of the earliest period of the history of logic. This department of the history of ancient literature would be disproportionably extended, and become wearisome to juvenile readers, if but a faint outline were attempted, and much more, if we were to present a detailed account of *all* the systems of logic taught in the Grecian schools of philosophy. The Academics, the Peripatetics, and the Stoics, were confessedly the most celebrated sects; and their respective founders, Plato, Aristotle, and Zeno, are recognized as the great masters of the dialectic art, to whom, by the undivided voice of antiquity,

has been awarded the honour of having taught men to reason scientifically and systematically. A summary view will therefore be given of the dialectic rules inculcated on their disciples by each of these celebrated masters, commencing with the logic of Plato, and the Academicians.

117. Plato, having been a disciple of Socrates, not only imbibed his philosophy, but adopted, in a great measure, the *Socratic* method of instruction. His discourses and writings, whether they relate to physical, logical, or metaphysical subjects, chiefly consisted of dialogues, arranged with consummate art, and clothed in a diction so elevated, that the ancient Greeks were accustomed to say, " If Jupiter were to speak in their language, he would borrow the style of Plato." In these supposed conferences, the philosopher does not appear in his own character, nor does he directly state his own opinions; but puts his most convincing arguments into the mouth of certain philosophers, who were then held in high estimation. Whatever advantages attended this mode of instruction, it was attended with some injurious consequences, since it left the unpractised mind in a state of sceptical uncertainty, balanced between opposite theories and arguments, and incapable of distinguishing truth from error. On this account, he is severely censured by Cicero, who, though a zealous Platonist, charges that philosopher with a disingenuous concealment of his own opinions, and with leaving the questions he professes to discuss wholly undetermined. It is, however, but just to

add, that this concealed method of philosophizing had probably been borrowed from the Egyptian priests, with whom he had associated in early life, and was strengthened by the danger which Socrates had incurred by adopting a contrary line of conduct. Whether designed or not, it is certain, that amidst all the poetical charms with which even his most abstract writings are invested, the main question of the dialogue is either covered with an impenetrable veil of obscurity, or so long kept in suspense by minute detail and colloquial interruptions, that the most attentive reader can with difficulty follow the thread of argument, and looks in vain for a general conclusion.

118. Plato divides philosophy into three great branches; viz. *dialectics,* or the art of reasoning; theoretic inquiries concerning God, nature, the human soul, matter, and the like, all of which he included under the term *physics;* and practical rules, concerning life and manners, to which was given the appropriate name of *ethics.* At present we have only to do with the first of these divisions of philosophy.

The science of *logic,* or *dialectics,* was divided by the Academic philosophers into five parts; namely, Division, Definition, Analysis, Induction, and Syllogism. The three former of these were considered as regarding chiefly the essences of things; the two latter, as comprehending their accidents or modifications.

(1.) *Division* denoted that part of logic which separates essences, which discriminates between genera and species, or which distributes the whole into its essential parts; as when man is considered a material and spiritual being, or when the human mind is contemplated as consisting of perception, memory, association, and the like. This is again subdivided into division of *essences,* of *accidents,* and of *terms* or words.

(2.) *Definitions* were considered as the result of such distributions, or the expression of the genera of things in connexion with their specific differences; as when man is described as an animal possessed of certain properties, or endowed with certain faculties, both mental and corporeal.

(3.) *Analysis* describes the process by which the mind advances from sensible to intellectual objects, which Plato terms *intelligibles.* These he subdivides into three classes; viz. *primary intelligibles,* comprehending those objects of human knowledge which admit of demonstration; *secondary intelligibles,* or indemonstrable propositions, though attended with a high degree of probability, and sustained by inferential reasonings; and *hypothetical intelligibles,* under which are included all conjectural or supposititious arguments.

(4.) *Induction* signified, in the Platonic school, (what it still denotes), the progress from individuals to universals, or the discovery of general principles by means of connected and successive facts. In addition, however, to this, Plato included under this term, reasonings from analogy, or arguments founded on real or supposed resemblances.

(5.) *Syllogisms* were invented by Plato for the purpose of deducing legitimate conclusions from intermediate propositions. These were subdivided into categorical, hypothetical, and mixed syllogisms. The *categorical* were those which consisted alone of axioms, or self-evident propositions, the truth and certainty of which could not be questioned; the *hypothetical* were composed of arguments which were assumed, or admitted of controversy; and the *mixed* were those in which arguments were built on consequences, rather than antecedent or previously established truths. For the scientific construction of these several kinds of syllogisms, numerous rules are given, with suitable illustrations.

119. The preceding sketch includes the most important subjects included in the dialectic system, introduced by Plato, and propagated by the Academic philosophers. They are preserved in several Dialogues, which are the undoubted productions of that celebrated philosopher. Of fifty-six, four treat of logic directly and avowedly, and several others indirectly and partially. The dialectic dialogues are entitled *Cratylus, Parmenides*, the *Sophist*, and the *Politician;* the first of which relates chiefly to the correct use of words and terms, together with the laws of definition; the second, to the arrangement and classification of ideas or objects of perception; the third, to the rules of true and false reasoning; and the last is of a more mixed character, and intended chiefly to illustrate the rules of logic, by applying them to controversies then existing, which greatly divided public opinion.

Besides these, which are expressly dialectic, there are other dialogues which indirectly bear on the science, such as his *Euthydemus*, which was intended to explain the nature of sophisms, and expose the artifices of the Sophists; and his *Protagoras*, in which rules are laid down for the detection of false reasoning.

SECTION III.

ON THE DIALECTICS OF ARISTOTLE AND THE PERIPATETICS.

120. WHEN it is recollected that the logical writings of Aristotle were not only celebrated throughout the Grecian states and the Roman empire, so long as literature continued to flourish there, and formed the principal basis of all the treatises subsequently written on that science, but that they retained their ascendency during the long period of intellectual darkness which followed the subversion of the Roman empire, when almost every other ray of science was extinguished; and still more, when it is remembered, that even to the present day they form parts of the system of education adopted both in British and foreign universities, it must assuredly be felt to be more than a mere matter of literary curiosity to know what those writings contain, and to what they owe their unparalleled celebrity. Though the idolatry of Aristotle has ceased in modern times, and his scholastic logic has given place to a more en-

lightened species of dialectics, we cannot but feel a sentiment of respect approaching to veneration for works which evince the highest order of literary talent, and which governed, with absolute authority, the opinions of mankind during a period of nearly two thousand years. All the writings of Aristotle, and especially those which relate to logic, are exceedingly abstruse, arising partly from the nature of the subjects themselves, but still more from the veil of obscurity which he designedly threw around them. To this studied concealment he was prompted by the ambition which rendered him desirous of establishing a new sect, and transmitting his name to posterity as the *Prince of Philosophers.* "His writings," says Dr. Reid, in his excellent analysis of the logic of Aristotle, "carry too evident marks of that philosophical pride, vanity, and envy, which have often sullied the character of the learned. He determines boldly things above all human knowledge, and enters on the most difficult questions, as his royal pupil (Alexander of Macedon) entered upon a battle, with full assurance of success. He delivers his decisions oracularly, and without any fear of mistake. Rather than confess his ignorance, he hides it under hard words and ambiguous expressions, of which his interpreters can make what they please. There is even reason to suspect that he wrote often with affected obscurity, either that the air of mystery might procure great veneration, or that his books might be understood only by the adepts who had been initiated into his philosophy."

Lord Bacon, when adverting to the literary character of Aristotle, has remarked concerning him with equal truth and beauty, "that his ambition was as boundless as that of his royal pupil, the one aspiring at universal monarchy over the bodies and fortunes of men, the other over their opinions;" and when censuring his disposition to detract from the merit of other philosophers (not excepting even Plato, under whom he had studied twenty years), Bacon sarcastically remarks, "After the manner of Turkish despots, he thought he could not reign securely unless all his brethren were slain."

121. The celebrity which the works of Aristotle subsequently attained, give an additional interest to the curious circumstances which attended their preservation. All the writings of this great philosopher were bequeathed by him, together with his library, to his friend Theophrastus, who preserved them with the utmost care, both from attachment to his preceptor, and his love to general literature. Theophrastus, at his death, left them to his disciple Neleus; by whom they were buried in a vault at Scepsis, a city of Troas, in order to secure them from the king of Pergamus, who was collecting MSS. from every quarter for his library. Previously, however, to their concealment, part of the works of Aristotle had been sold to Ptolemy, king of Egypt, and were by him deposited in the Alexandrian library; whence it is probable that they became known, though in a mutilated form, to the Arabians and Saracens. The entire original works were lost sight of more than 160 years, when they

were discovered and sold to a rich citizen of Athens. Sylla, the Roman dictator, brought them from Athens to Rome, where they subsequently came into the possession of Tyrannus and Andronicus of Rhodes, who caused copies to be transcribed, and by whom they were introduced to the attention of the Roman philosophers. Still, however, many years elapsed before they acquired popularity in the Roman empire. It was not till after the commencement of the Christian Æra, and after many learned commentaries had been written upon them by the eclectic philosophers, that they obtained the ascendency which, it will hereafter appear, they maintained through a long series of ages. At present we have only to do with that part of the writings of this great philosopher, which relates to the dialectic art.

122. The logical writings of Aristotle, though published as separate treatises, have been long since collected into one volume, entitled *Organon*, to which is usually prefixed *Porphyry's* Introduction. The Organon contains, (1.) *The Categories*, which treat of Terms, in one book; (2.) *Interpretation*, or *Definitions*, (a treatise partly grammatical and partly *dialectic*), in one book; (3.) *Analytics*, including the whole doctrine of syllogisms, in four books; (4.) *Topics*, or materials for reasoning and demonstration, in eight books; and (5.) *Sophistics*, or *Sophisms*, containing an explanation of all the varieties of false reasoning, in one book. These are all the logical dissertations contained in the *Organon*; but many others are

mentioned by ancient writers, which are lost, and consequently the contents of which can only be conjectured from brief extracts. Passing over Porphyry's Introduction, which, though an useful commentary on the logical system of Aristotle, belongs not properly to the dialectics of that philosopher, we shall proceed at once to give a brief analysis of the principal contents of the *Organon.*

123. *Logic,* as defined by Aristotle, is "the art of searching for and discovering truth." This important science he divides into two great branches,—*analytics,* which investigates truth by incontrovertible demonstration; and *dialectics,* which establishes it by probable arguments. To the former of these is assigned the primary station in the operations of mind, while to the latter is assigned but a secondary importance.

Terms are considered as the elementary parts of logic, and therefore occupy the first place in the Peripatetic system. These are either *homonymous, synonymous,* or *paronymous:* the first, comprehending those objects of human knowledge, which, though differing in their qualities or accidents, are expressed by one name or term; the second, those in which the name and definition coincide, or in which the same object is expressed by different terms; and the third, those which agree in general signification, but differ in their accidental forms of case or termination. Corresponding to the above are the three distinctions of *univocal, equivocal,* and *denominative* terms.

124. The way being thus cleared for the scien-

tific and logical arrangement of terms, Aristotle proceeds to the enumeration of his celebrated *Categories,* which were supposed to comprehend all the objects of human knowledge, and constituted the chief boast of the Peripatetic school. These were *ten* in number, because that quantity was considered by the Pythagoreans sacred, and indicative of perfection. Some of the Categories relate, however, to mere verbal distinctions, the precise idea of which it is difficult to express by any single terms in our language.

(1.) *Substance;* subdivided into primary and secondary.

(2.) *Quantity;* which is either discrete, as numbers, or continuous, as lines, &c.

(3.) *Relation;* shewing how one thing is affected by another.

(4.) *Quality;* of which there are four kinds: habit and disposition, power or weakness, passible qualities or passions, and form or figure.

(5.) *Action;* including all terms that express motion or change of place.

(6.) *Passion;* or the state of the substance moved or acted upon.

(7.) The *when;* comprehending all terms expressive of *time.*

(8.) The *where;* or those which relate to *place.*

(9.) *Situation,* or *position;* including terms descriptive of local relations.

(10.) The *having,* or *possession;* comprehending all terms descriptive of property.

These far-famed *Categories* have been applauded by the followers of Aristotle, as comprehending every idea that can enter into the human mind, and a most perfect classification of all possible modification of language; yet, notwithstanding this boasted perfection, subsequent dialecticians have presumed to augment them, by annexing several supplementary articles, such as, *opposition, priority, coincidence, &c. &c.;* all of which, together with the greater number of the categories, might be included under the generic title of *accidents.*

125. From the classification of *terms,* Aristotle proceeds to *propositions.* After having taken a comprehensive and philosophical view of the principles of universal grammar, as regulating the due arrangement of words in sentences, and establishing their mutual relations; the various kinds of enunciations, or propositions, are minutely described under the several heads, of simple and complex, universal and particular, pure and modal; the latter of which are further subdivided into necessary and contingent—possible and impossible, &c. &c. To these, which were considered as the essential qualities of propositions, several others were added, which were called accidental; (1.) Those of *Opposition,* including contradictory, contrary, and sub-contrary. (2.) *Consectation,* or those which were of equivalent or *equal force;* and (3.) *Conversion,* or those which involved a *transposition of terms.*

126. From *propositions,* Aristotle proceeded to *syllogisms,* which, though invented by Plato, or probably some yet earlier dialectician, form a distinguishing feature of the Peripatetic logic.

Innumerable rules and directions are given for the construction and logical arrangement of these modes of reasoning. They are discussed with a degree of minuteness and subtilty, that affords an astonishing proof of the ingenuity and industry of their inventor; but to enter into the detail would be both tedious and unprofitable. The rules laid down for the constitution of perfect and imperfect syllogisms, their division into moods and figures, and the artificial expedients resorted to by which to distinguish them, have long since become matters of literary curiosity, rather than subjects of profitable investigation. By not distinguishing carefully between words and ideas, and intermingling didactic rules applicable to both, this branch of the logical system of Aristotle is rendered unnecessarily obscure and complicated.

127. This celebrated logician proceeds from *syllogisms* to another division of his *analytics,* which he technically terms *apodeictics,* or *demonstration.* Under this head are arranged all those propositions or trains of reasoning, which relate to self-evident truths, and involve in them, by immediate and necessary consequence, the conclusion to be demonstrated. This is perhaps the most valuable part of his dialectic writings, and that which may be best applied to practical purposes. These are subdivided into necessary, universal, and eternal truths, as opposed to fortuitous, individual, and temporary positions, which from their nature do not admit of demonstration. But the most important distinction suggested by Aristotle on this subject,

and which is still adopted by *logicians*, is, the *demonstration of the fact*, or that process of reasoning by which a thing is proved to be what it is, and the *demonstration of the mode*, or that which proves the manner of its existence, and explains *why* it is so. The latter of these is reckoned a perfect demonstration.

128. The next division relates to *dialectics*, (proper), by which, as distinguished from *analytics*, was intended, the deduction of conclusions or inferences from *probable* premises, not axioms and self-evident truths. This is described as a conjectural art, which may be usefully employed by way of experiment for the advancement of science; but with which the mind, intent upon the discovery of truth, will not be satisfied. Dialectic propositions express genera and their differences, definitions, properties, accidents, qualities, &c. &c. They shew to what class any subject belongs, what are its properties and qualities, together with all the casual circumstances which may attend them. Many minute and subtle distinctions are introduced into this part of his system, which it would be tedious to enumerate.

129. The last division of the *Organon* relates to *Sophistics*, or fallacious reasonings. As in the former part of his logical writings numerous rules were given for the construction of syllogisms, as instruments of correct reasoning, here he shews in how many forms those rules may be violated, and error substituted for truth. Every syllogism, intended for the refutation of arguments adduced by an

opponent, is termed an *elench.* These may be either true or false. The former alone will be employed by those who aim at the discovery and propagation of truth; the latter belongs to *sophists,* who have no other aim than to perplex an adversary, or propagate error.

130. *Sophisms* may relate, (1.) To the *terms* of a proposition, of which kind six varieties are enumerated; viz.

1. *Homonymics,* when ambiguous words are employed in different senses.
2. *Amphibolics,* when the sentence is ambiguously constructed.
3. *Sophisms* by *composition,* when that is affirmed of a thing in a state of combination, which is only true in its simple state.
4. By *division,* which is the opposite error to the preceding.
5. By *accent,* when persons are misled by pronunciation.
6. By *figure,* which consists in reasoning from the literal to the figurative meaning of words, or *vice versâ.*

Or, (2.) They may relate to the *subject* of the proposition, of which seven kinds are enumerated; viz.

1. *Sophisms* by *accident;* or affirming that to be essential which is only accidental.
2. Those which are produced by applying the simple to the compound, and *vice versâ.*
3. Ignorance, or wilful mistake of the *elench* or argument.

4. Assigning a false or unsatisfactory reason.
5. Begging the question, or assuming that which is to be proved.
6. Drawing false conclusions, unsupported by the premises.
7. Proposing a series of questions, which require different answers.

Besides these principal divisions of Sophisms, four other false modes of reasoning are minutely described; to which are given the appropriate names of *falsity*, *paradox*, *solecism*, and *tautology*.

131. The preceding is but a brief and very imperfect sketch of that stupendous effort of human ingenuity, which has rendered the name of Aristotle imperishable in the annals of literature. Perhaps it cannot be more appropriately concluded, than by introducing his own judicious remarks on the state of the science of logic before his time, and the design with which his "Analytics" were composed; only premising that, however just may be his censure of the *Sophists*, he ought not to have passed over in silence his great master, PLATO, under whom he had studied twenty years, and to whom he was indebted for some of those inventions, the honour of which he arrogated to himself.

"Of those who may be called inventors, some have made important additions to things long before known; others have made a small beginning to things, which succeeding ages brought to perfection. The beginning of a thing, however small, is its chief part, and requires the greatest degree of invention; for it is easy to add to inventions once begun. Now, with regard to the dialectic art, there was not something done and something remaining to be accomplished: there was absolutely nothing done; for those who professed the art of disputation had only a set of orations, oomposed of captious questions and false arguments, systematically arranged, which might suit many occasions. These the scholars soon learned, and sought occasions to apply; but this was not to teach the art of reasoning; it was only to furnish a few of those materials which that art is intended to produce." Then, alluding to his own logical treatises, he adds, "we have employed much time and labour in this subject; and if our system appear not to rank with those things, which, having been before carried to a certain extent, is rendered perfect and complete, yet we will hope for your favourable acceptance of what is done, and your indulgence wherever it is left imperfect."

SECTION IV.

ON THE LOGIC OF ZENO AND THE STOICS.

132. THE celebrity of the class of philosophers to which this section refers, the long series of ages through which they continued to flourish, and the influence they exerted on the literature both of Greece and Rome; all these, and many other circumstances, render it an object of importance to ascertain what were the tenets which characterized

their philosophical system. This will be more properly investigated in the next chapter, when the metaphysical opinions of the ancient philosophers will be briefly reviewed. But in the mean time, the dialectics of the Stoic school form too important a part of their system to be passed over unnoticed, and the rather as they differ materially from those of Plato and Aristotle. Though the great founder of the Peripatetic sect must be acknowledged to have been the chief inventor of the dialectic art, and to have carried it to the highest degree of perfection, the rise of the Stoic sect, under the auspices of Zeno, must also be acknowledged to constitute an æra of considerable importance in the history of logic. It will, however, appear, from the following sketch, that this science, as taught in the Athenian Porch, was so intimately blended both with the rhetorical art, and with the speculations of mental philosophy, that it is impossible to keep them wholly distinct. The Stoic philosophy was, in reality, an ingenious combination of the tenets and doctrines of several preceding sects. In *physics*, it resembled the Pythagorean and Platonic systems; in *ethics*, it partook of the character of the Cynic and Heraclitean; and in *dialectics*, it united the subtilties of the Sophists with the science and method of Aristotle and the Peripatetics. Of this statement, the writings of Cicero, Seneca, Antoninus, Epictetus, and especially of Sextus Empiricus, afford most convincing proofs.

133. *Zeno*, the Stoic, divided philosophy into three parts—namely, physics, ethics, and logic; cor-

responding with the three classes of virtues—natural, moral, and rational. Logic, which relates to the exercise of reason, consists, according to the Stoics, of two parts—rhetoric and dialectics; the former of which divisions comprehends all declamatory discourses, and appeals to the passions of mankind; the latter, argumentative discourses, or reasoning by syllogism and dialogue. The great object of the first is to persuade—of the latter, to convince. Rhetoric, considered as a branch of logical science, is of three kinds—deliberative, judicial, and demonstrative. Its principal parts are, invention, style, disposition, and pronunciation. Each of these is subdivided into many subordinate parts, which, as they do not properly belong to the science of logic, it is not necessary to enumerate. The *dialectic art* was defined by Zeno to be, "that by which truth is distinguished from error, and by which the mind is enabled to arrive at absolute certainty or demonstration."

134. As there can be no reasoning without ideas, an inquiry was first instituted by the founder of the Stoic sect into the origin of notions, and the manner in which they are produced in the mind. The source of all knowledge was conceived to be sensation. Impressions made on the brain, through the medium of the senses, (to which, as images of external objects, was given the name of *phantasies,)* led to perception, apprehension, knowledge, opinion, judgment, and all the various phænomena of mind. The notions, or ideas, thus produced, were divided by Zeno, as they have subsequently been divided by

Locke, into two classes, sensible and rational; intending by the first, those which are derived immediately from sensation, and by the second, those obtained by reflection, or the action of the mind in itself. These are subdivided into probable and improbable, doubtful and false. The phantasies, or images of external objects, are either immediate, as when we look on the individual himself; or consequential, as when the view of a portrait calls up the image of the person it represents; or compounded, as in the case of a landscape; augmented or diminished, as when we look at a giant or dwarf.

135. Having laid the foundation of his logical system, in these and many similar metaphysical distinctions and speculations, Zeno proceeded to the more definite object of the science, and inquired into the origin of language—the varieties of vocal sounds—words, as arbitrary signs of ideas, the elementary parts of speech, the relations, affinities, powers, and modifications of terms, when variously arranged in sentences—and the properties of style. According to this philosopher, the chief excellencies of style are, perspicuity, propriety, brevity or compression, decorum and elegance: its principal faults—barbarisms, solecisms, and anomalies. From words separately considered, or as grouped together in sentences, he advanced to *definitions*, their various kinds and essential qualities; in which he seems to have closely followed the track marked out by Aristotle, in his books of "Interpretation" and "First Analytics." The distinctions and rules suggested on this subject, will be found in almost

every treatise on logic, which has been since published.

136. The next step in the logical system of the Stoics, was the classification of the objects of human knowledge into *genera* and *species;* terms which were then employed in nearly the same sense as that attached to them by modern logicians. The principal divisions of genera are, real and imaginary existences; and these are again classified by terms which nearly correspond with the words *substances* or subjects, *qualities* or adjuncts, *modes,* and *relations.* Then passing once more from thoughts to words, all objects of thought that can be expressed are termed *dicibles;* which admit of innumerable modifications, such as interrogative, imperative, hypothetical, &c. Advancing to *propositions,* the nature and properties of predicates (technically termed *categorems)* are minutely described, and their varieties distinguished. Of these, the most important are *axioms,* which are either simple or compound, possible, probable, necessary, connective, disjunctive, with a thousand other equally trifling distinctions.

137. *Reasons,* or arguments, occupy nearly the same place in the logic of the Stoics, as syllogisms in that of Aristotle. They are divided into conclusive and inconclusive, the former of which (as the terms import) denote those arguments which are legitimately conducted and lead to the discovery of truth; and the latter, those which are imperfect or sophistical. Great attention was paid by the Stoics, as well as all other classes of ancient dialecticians,

to the various kinds of *Sophisms*, the detection and refutation of which are of so great importance in debates. These were divided into the quiescent, the false, the occult, the inexplicable, the reciprocal, the defective, with many others.

Finally, *Method*, or the general mode of conducting arguments, occupied an important place in the dialectics of Zeno. The chief distinctions made on this subject were, the philosophical and the vulgar. The *philosophical* method consisted in the scientific employment of all the didactic rules previously suggested, relative to definition, division, and syllogistical reasoning: the *vulgar*, or popular method, might be pursued either by continuous oration or colloquial discussion. The former method is recommended as best fitted to the exposition of the arts and sciences, and the latter as most useful in disputation and controversy.

138. The sketch of the logical systems of the Academic, Peripatetic, and Stoic sects, which has been attempted, may perhaps suffice for the review of this department of ancient science. It would have been easy to extend it, by alluding to the dialectics of other sects, or by presenting the juvenile reader with analyses of other logical works; but it is conceived that this would be neither desirable nor advantageous in so elementary a work as the present. The only additional work on the subject which claims a distinct notice, is, the "*Canonica*" of Epicurus, which is partly metaphysical and partly dialectic. Having premised that "Truth is of two kinds, that which respects real existences, and that

which consists in a perfect agreement between our mental conceptions and the nature of things," he proceeds to enumerate and classify the criteria by which truth may be discerned. These are the three following, which are the great instruments employed by the human mind in forming its judgments, viz. *sensation, preconception* or anticipation, and *passion* or affection. On each of these, several general principles, termed by Epicurus *canons,* are laid down as rules to assist the understanding in its search after physical or moral truth. These canons, though highly curious, and in some degree useful, it would be tedious to enumerate.*

SECTION V.

GENERAL REMARKS ON THE DIALECTICS OF THE ANCIENTS.

139. THE preceding review of the dialectics of Plato, Aristotle, Epicurus, and Zeno, may, it is feared, seem dry and uninteresting to such juvenile readers as have not paid any attention to *logic.* For their sakes, therefore, we shall step aside for a moment from the direct object of these pages, which is, the recital of historic facts connected with the

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* A summary of the principal contents of the *Canonica* of Epicurus, will be found either in the ancient biographical history of Diogenes Laertius, in the philosophical writings of Sextus Empiricus, or in Stanley's Lives of the Philosophers, p. 851—856.

progress of general knowledge, in order to shew that this science, (forbidding as it may appear, and formidable as was the array of technical terms, with which it was formerly encumbered), is of great utility and importance. That a contrary opinion should be entertained by many, can excite no surprise, when it is considered that, in succeeding ages, this art was solely applied to the most frivolous and useless *logomachies;* that the study of logic superseded, at one time, every other exercise of the human mind, and even usurped the place of the Sacred Volume itself; and that, in modern times, names of considerable authority can be cited, by whom the dialectic art has been held in sovereign contempt. To remove such prejudices, it is only necessary to turn from the contemplation of the abuses and perversion of this art, which were the combined result of ignorance and folly, to the objects which it proposes to attain, and for the attainment of which, under the guidance of sound judgment, it is well adapted. It may be proper, too, to distinguish not only between the interminable disputations of the Sophists, but also the scholastic refinements and subtilties of the Peripatetic philosophers, and the true science of logic.

140. The objects of logic, as stated by the ancients themselves, are, the exercise and improvement of the rational faculties, the exposure of error, and the discovery of truth; and who will say that these are objects of subordinate importance? With respect to the former of these, it is admitted that the mathematical sciences tend more directly and effectually to the attainment of that desirable end; they require so much abstraction of thought—they include such lengthened trains of connected reasoning—they yield such perfect satisfaction and conviction,—that the vigorous application of the powers of the understanding to these sciences, cannot fail to impart to them a tone and energy which otherwise they would not possess. But next to these, which unquestionably occupy the highest rank in practical utility, it may be safely affirmed, that logic occupies no mean place, and exerts no ordinary influence on the intellectual faculties. For what is logic, but a development of those principles on which mathematical reasonings are founded, and a systematic classification of the elements of mathematical knowledge? A modern writer of considerable eminence has, therefore, most fitly termed mathematics "the noblest praxis of logic." "Is it," says Dr. Reid, "of no use in reasoning, to be well acquainted with the various powers of the human understanding, by which we reason? Is it of no use to resolve the various kinds of reasoning into their simple elements, and to discover, as far as we are able, the rules by which these elements are combined in judging and reasoning? Is it of no use to mark the various fallacies in reasoning, by which even the most ingenious men have been led into error? It must surely betray great want of understanding to think these things useless and unimportant. Yet these are the things which logicians have attempted, and which they have executed,—not indeed so completely as to leave no room for improvement, but in such a manner as to give very considerable aid to our reasoning powers. That the principles laid down with regard to definition and division—with regard to the conversion and opposition of propositions and the general rules of reasoning—are not without use, is sufficiently apparent from the blunders of those who disdain any acquaintance with them."—*Reid's Analysis*, chap. v. sect. 1.

141. Such being the objects of logic, its general utility must be apparent; but it may still be questioned, with reference to the dialectics of former ages, and especially the logic of Aristotle, how far they were fitted to attain the proposed end? That these are curious and venerable monuments of antiquity, few who are acquainted with them will feel disposed to question; and that these are parts of the ancient systems of logic, which, being founded in reason and truth, must prove permanently useful, and have consequently formed essential parts of all modern treatises on the subject, is equally evident. None can regret that the idolatry and despotism of Aristotle have ceased; nor can any one seriously wish that the period should return in which the *Categories* should be venerated, as the most perfect classification of the objects of knowledge; or that all the moods and figures of *syllogism* should be again distinguished by barbarous technical phrases, though they were not wholly without their use. It is well that these are now regarded rather as matters of literary curiosity, than as constituting parts of a logical education. Yet if we reflect on the necessity of accurate discrimination in order to dis-

cern things that differ, and the importance of method to success in almost every undertaking, we cannot but be convinced that the rules of syllogistic reasoning, and the methodical arrangement of ideas and propositions, which logic suggests, may assist both in the detection of error, and the development of truth. And here, in confirmation of these remarks, the writer cannot forbear to cite once more an author, who certainly cannot be justly accused of an undue deference to the authority of the ancients. "There is perhaps no practical art which may not be acquired, in a very considerable degree, by *example* and *practice*, without reducing it to rules. But practice, joined with rules, may carry a man further on in his art, and more quickly than practice without rules. Every ingenious artist knows the utility of having his *art* reduced to rule, and by that means made a SCIENCE. He is thereby enlightened in his practice, and works with more assurance. By rules he sometimes corrects his own errors, and often detects the errors of others. He finds them of great use to confirm his judgment, to justify what is right, and to condemn what is wrong." Alluding more particularly to the ancient dialectics, the same writer remarks most justly, that "although the art of categorical syllogism is better fitted for scholastic litigation than for real improvement in knowledge, it is a venerable piece of antiquity, and a great effort of human genius. We admire the pyramids of Egypt, and the wall of China, though useless burdens on the earth; — we can bear the most minute description of them, and travel hundreds of leagues to see them: if any person should, with sacrilegious hands, destroy or deface them, his memory would be held in abhorrence. The predicaments and predicables, the analytics and topics, the rules of syllogism and the dialectics of ancient philosophy, have a like title to our veneration as antiquities. They are uncommon efforts, not of physical power, but of human genius, and they make a remarkable period in the progress of human reason."—*Reid's Analysis of Aristotle's Logic,* c. v. sect. 1.

CHAPTER VI.

ANCIENT METAPHYSICS.

SECTION I.

ON THE ORIGIN AND PROGRESS OF METAPHYSICAL SCIENCE AMONG THE PHILOSOPHERS OF GREECE.

142. THE present work being chiefly intended for the instruction of youth, it would be evidently improper to enter far into this department of ancient literature. It could answer no valuable end to conduct the young inquirer through all those mazes of abstract speculation, in which the philosophers of antiquity indulged, and amidst which minds of maturer growth have been perplexed and bewildered. The detail would be both uninteresting and unprofitable. Yet, as these speculations form an essential part of the history of ancient philosophy, it would be improper to pass them over unnoticed. It will be therefore attempted, in this division of our historical review, to make a selection, and exhibit, in as simple a form as possible, the distinguishing tenets of the most celebrated philosophers and the principal sects, passing over those which, either on account of their vagueness or their absurdity, may justly be consigned to perpetual oblivion. From the distinction suggested in the introductory chapter, it will be apparent that the division of

science, to which we now refer, is that which relates to *mind* as distinguished from *matter*, and that the topics it includes are the opinions and speculations of the philosophers of antiquity relative to the Deity; the human soul; its nature, properties, powers, and operations; spiritual existences; and whatever other subjects of human investigation obviously arose out of one or other of these objects of intellectual research.

143. In reviewing the literary history of oriental nations, allusion was made to some of the metaphysical tenets maintained by the philosophers of the East; and it will be perceived, in the sketch about to be given, that the metaphysics of the Grecian philosophers partook of the same character, and probably had one common origin. It is difficult to ascertain the precise æra in which metaphysical science originated in Greece, or by whom it was first introduced. Some of the most ancient philosophers, both of the Ionic and Italic sects, speculated on the nature and properties of the human soul, and framed some crude and conjectural theories relative to the perceptive and sentient faculties of man; but these speculations were so completely visionary, and so blended with physical and material phænomena, as scarcely to deserve attention. If by the term *metaphysicians*, as already defined, be meant that class of philosophers, whose researches were principally directed to the phænomena of mind separately from those of matter, scarcely can it be affirmed that any approach was made towards a metaphysical system

by any of the Grecian sects, till the æras of Plato and Aristotle. To the theories of these fathers of ancient philosophy, our attention will therefore be chiefly directed at present. Yet as it is desirable to trace the stream of knowledge as far back as possible towards its native source, we shall first glance at the advances made in this department of science, before the periods to which we have just alluded.

144. The first of the philosophers of Greece, who seems to have formed any conception of an immaterial intelligent agency, was *Anaxagoras*, a philosopher of the Ionic sect, who flourished about A.C. 440. It may be gathered, from ancient records, that this distinguished philosopher taught his disciples to attribute the formation of the universe, not, as his predecessors had done, to blind chance or fate, or inert matter, but to an infinite mind, which had a continued and separate existence, independently of the material universe. Of the metaphysical system of Anaxagoras (if system it may be called), the following summary has been given:—"The most important improvement in philosophy suggested by this philosopher was that of separating the active principle in nature from the material mass upon which it acts, and thus introducing a distinct intelligent cause of all things. The similar particles of matter, which he supposes to be the basis of nature, being without life and motion, could not produce themselves; and, therefore, he concluded that there must have been, from eternity, an intelligent principle or infinite mind, existing

separately from matter, which, having the power of motion within itself, communicated it to the material world, and thus produced the various forms of nature." On account of this distinguishing and important feature of his system, this philosopher was honoured with the title of *νους*, or *mind;* "for,' says Laertius, in assigning the reason for that appellation, "*he* first joined that agent to matter, by which order arose out of confusion."

145. The opinions of Pythagoras and his followers on the subjects now under review, nearly accorded with those stated above. The founder of the Italic sect had been so thoroughly initiated into the mysticism of the Egyptian priests, and conveys his instructions in such symbolical language, that it is frequently difficult to perceive what his opinions really were. As far as they are intelligible, the following summary gathered from the records of antiquity may be considered as comprehending the principal tenets of the Pythagorean philosophers.

(1.) Respecting God, it was maintained, that He is the universal mind diffused through the whole system of nature; the source of animal life, the sole cause of motion; in substance similar to light, impassible, invisible, incorporeal, eternal, and only to be comprehended by the mind. Justin Martyr, one of the christian fathers of the third century, has quoted the following passage from the writings of a philosopher of this sect, as containing their theistical creed:—"God is one. He is not, as some suppose, exterior to the world, but in himself entire; pervades the universal sphere, superintends all pro-

[illegible] of all [illegible]:—the [illegible] from—the [illegible] of all—the mind [illegible] the first [illegible]." Another of the Pythagorean [illegible] the Deity, "the self-moving principle of all things."

(2.) Respecting the orders of intelligent Existences, subordinate to the Supreme Divinity, it was maintained, that there are three, which fill up the interval between God and man; viz. gods, dæmons, and heroes, who are distinguished by their degrees of excellence, and the proportionate homage due to them. These were represented by the Pythagorean system as emanations from the Supreme Intelligence, possessing a greater or less degree of [illegible], as they approximated to or receded from the fountain of life. Heroes, who constituted the lowest of these orders, were supposed to be invested with a subtile material clothing, more refined than the gross matter of which the human body is composed, yet essentially different from pure spirit. The definition given by one of these philosophers distinctly conveys this idea: "A hero," said Hierocles, "is a rational mind united to a luminous body." If to these three species be added the human mind, the whole scale of divine emanations, as taught in the Italic schools, will be perceived.

(3.) Respecting man, it was maintained, that his nature consists of two essential parts; one of which is elementary and material, the other intellectual and spiritual; for which reason he is to be accounted a *microcosm,* or compendium of the universe. The soul is also composed of two parts,—the rational, which includes all the powers of the understanding —and the sensitive, or irrational, which includes the appetites and passions. The sensitive soul is subject to decay, and eventually perishes — but the rational mind is immortal and imperishable, like the divine Intelligence from which it proceeds. With the philosophers of the East, from whom the system was probably derived, Pythagoras taught the doctrine of transmigration; or that, after the rational mind is freed from the incumbrances of the body, it assumes an ethereal vehicle, and passes into the regions of the dead, whence it returns to inhabit some other body, either brutal or human, thus passing through a long series of purgations, till it is completely purified and reabsorbed in the divine nature.*

146. Many of the Grecian sects, which arose out of the Ionic and Italic, may with propriety be passed over in this outline of ancient metaphysics; because they denied altogether the existence of

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* One of the Roman poets has thus described the Pythagorean notion of *metempsychosis*, or *transmigration :*

> "What then is death, but ancient matter, drest
> In some new figure and a varied vest;
> Thus all things are but altered; nothing dies;
> And here and there th' embodied spirit flies,
> By time, or force, or sickness dispossess'd,
> And lodges where it lights, in man or beast;
> From tenement to tenement is tost,
> The soul is still the same—the figure only lost."

mind as distinct from matter, and were either advocates of the most absurd *atheism,* the grossest materialism, or universal scepticism. Such were the *Eleatic* philosophers, (with the exception of *Xenophanes, Parmenides,* and *Zeno,* who belong rather to the class of Pantheists and Idealists,) and the *Atomic* philosophers, of whom the most celebrated were *Leucippus, Democritus,* and *Epicurus.* These men, in the plenitude of their wisdom, discovered and taught, that the whole universe is made up either of *atoms* or *vacuum*—and that the former of these, by mere chance, came together, so as to form a well-regulated and beautiful world, with all its varieties of animate and inanimate beings. From these vagaries and absurdities, it is grateful to pass to a system which approaches nearer to rationality, and needed but the illumination of revealed truth to render it one of the sublimest developments of human genius. We refer to the metaphysical system of the earlier *Platonists,* a sketch of which will be attempted in the next section.

SECTION II.

ON THE METAPHYSICAL OPINIONS OF SOCRATES, PLATO, AND THE ACADEMIC PHILOSOPHERS.

147. WE are now entering on the review of that period in the history of Grecian philosophy, which is universally acknowledged to have been its most

splendid æra; that in which Socrates taught, and Plato flourished, and the Academic sects arose; that in which theoretic and speculative philosophy took its loftiest and boldest flights. We have already met with one of these celebrated philosophers in other departments of literature. The discoveries of Plato in physical science, and his dialectic system, have been briefly adverted to; but we now encounter him in his own province; in that division of science for which he is most celebrated, and in which he most excelled. When it is considered that the metaphysical speculations of Plato not only influenced the opinions, and pervade the writings of the most eminent philosophers of antiquity, but that the far greater number of modern metaphysicians (the venerated Locke himself not excepted) have also availed themselves of his labours and writings; and, most of all, when we reflect that Christianity itself was, after a short period from its first promulgation, modified and corrupted thereby; it may reasonably be expected that, in an elementary work, which professes to exhibit a brief but faithful outline of the philosophy of the ancients, the Platonic system should be distinctly noticed. It must be premised, that in that system, as well as in the speculations of the oriental philosophers, theology was so intimately blended with metaphysics, that however desirable it may be to keep them distinct, it is scarcely possible to furnish an intelligible outline of the one, without glancing at the other. The principal topics included in the Platonic system of intellectual philosophy may be thus arranged:

I. THE DEITY.

148. On this fundamental subject of human investigation, the opinions held by Plato and his followers were extremely confused and mystical; yet, as far as they are intelligible, they seem to have so little of the grossness of polytheism blended with them, and to have been so abstract and refined, as to render it highly probable that they were remotely derived, through the medium of corrupted traditions, from the Jewish scriptures. It was taught in the Academic schools, that there is one intelligent Cause—the origin of all spiritual being, and the framer of the material universe. The nature of this Supreme Intelligence was declared to be incomprehensible; though the marks of profound wisdom, and the *oneness* of design apparent through the whole system of nature, prove his existence, his unity, his supremacy, and his infinite understanding. He was further described as an incorporeal existence, without beginning, end, or change, and only discernible by the "*mind's eye*;" and that to him belong all those qualities which characterize immaterial substances, such as simplicity, ubiquity, and universal diffusiveness, or omnipresence. But, in addition to these general and abstract conceptions of the Deity, Plato seems to have formed the notion of some mysterious distinctions in the divine nature, to which he gives the name of *hypostases*. These some affirm to have been two, and others threefold. The titles given to them indicate *existence*, or *being*, in general—*mind*, or universal

intelligence, and *life*, or the principle of vitality, which was supposed to be diffused through the material universe. The first of these *hypostases* is represented as emphatically *the Being*, to denote self-existence and eternity. The second was considered as the *Wisdom*, the *Reason*, or, as he is expressly called, the *Logos of Deity*, as well as the Author of Creation, and the Son of God. The third was termed, *Anima Mundi*, or the soul of the world, which will be more fully explained hereafter. Scarcely is it possible not to perceive in these mystical *hypostases* of the Platonic system an obscure intimation of the scriptural doctrine of the *Trinity*, from whatever quarter it may have been derived.

II. NATURE, OR THE MATERIAL UNIVERSE.

149. On this subject the founder of the Academic sect wrote with so much obscurity, and enwraps himself in so impenetrable a veil of mystery, that it is difficult to collect what his real sentiments were. The dialogue entitled "*Timæus*," which principally treats of "the origin and nature of things," contains opinions and statements which, if not contradictory, are yet so dissonant, that it would require the utmost ingenuity of reasoning to reconcile them with each other. Whilst, on the one hand, he speaks of God as the "Parent of the universe"—as "the Creator of all things"—"by whom all animate and inanimate substances were produced, which previously had no existence;" on the other, he distinctly maintains the eternity of matter, and

seems to represent it as co-existent with and independent of the great First Cause. Cicero, in his "*Academic Questions*," thus states the Platonic opinions on this subject: — "Matter, from which all things are produced and formed, is a substance without form or quality, but capable of receiving all forms and undergoing every kind of change. It never suffers annihilation, but merely a solution of its parts, which are in their nature infinitely divisible, and move in portions of space which also are infinitely divisible. It is the mother and receptacle of all forms, by the combination of which, with matter, the universe becomes perceptible to the senses." These forms originating in the divine mind, and being subjected to divine energy, God must necessarily be the Creator of all things. Hence arose the distinction made by the Platonists between matter and body; the former signifying the eternal elements, from which the latter is produced in all its diversified forms: and for the same reason it was contended, that *incorporeal* substances may yet be *material*. But the most singular tenet of the Academics, in connexion with matter, was, the notion that it possessed a sort of blind and refractory force, to the influence of which the disorders and miseries which abound in the world were to be attributed; that inert and shapeless matter resists the will of the supreme artificer, so that he cannot perfectly accomplish his designs; and that this is the true cause of the mixture of good and evil apparent in the system of the universe. May not these speculations, erroneous as they were, be deemed the commentaries of human ignorance and imperfection, on the Mosaic narratives of the Creation and the Fall?

III. THE SOUL OF THE WORLD—(ANIMA MUNDI).

150. Among the strange conceptions of Plato, perhaps none is more remarkable than that which relates to the "soul of the world," which, as has been already stated, was considered an *hypostasis* of the Divine Nature, co-ordinate in time, but not equal in dignity to the rest. By this phrase, he seems to have intended, the principle of life immersed in matter, and forming with the material world which it inhabited, and was supposed to pervade, *one compound animal.* This governing spirit, of whom the earth, properly so called, is but the body, consisted, according to Plato, of the first matter, and of pure intelligence, so framed and combined together as to actuate the whole machinery of nature; it is the animating principle of the universe, giving to all things life and motion. The seat or residence of this mysterious agent was supposed to be the centre of the world, whence his power is described as emanating and extending in all directions to the utmost limits of the material universe, preserving an unbroken harmony in all its various and complicated parts. Upon this being, God is said to have looked with peculiar complacency, after having formed him as an image of himself, and to have given perfect beauty and proportion to the mansion he was destined to inhabit. This "*Life of the World,*" thus vivifying

with his presence, and pervading with his influence, all matter, is described as the highest object of divine complacency, and is sometimes designated expressly the *Son of God*. How otherwise (it may be asked) can this theory be rationally explained, than by supposing that some of those predictions of the Old Testament scriptures, which foretold the *incarnation of the Messiah*, the *Son of God*, had been communicated to the Grecian philosopher in a corrupted form, blended with the mythology of the oriental sages, and that the result of this unhallowed combination was, the heterogeneous theory stated above? It may be added here, that the later Platonic philosophers improved, as they supposed, on this dogma of their founder, by contending for a two-fold *anima mundi*, the one presiding over, and the other inhabiting the world; a theory which was grafted by some of the speculative christian fathers of the third and fourth centuries, on the christian system.

IV. IDEAS.

151. The notions entertained by Plato and the Academics on this most difficult subject, are so obscurely expressed, as to have perplexed the acutest metaphysicans both of ancient and modern times. As far as the ideal system of the Platonic school is comprehensible, it seems to have been briefly this—that *ideas* are the patterns or archetypes of all possible existences, subsisting by themselves as real *essences* in the Divine *Mind*, *Reason*, or *Logos*, as in their own eternal region, and issuing

thence at different periods, according to the will of the Deity, to give form to sensible objects, and become themselves in their turn objects of contemplation to rational minds. Plutarch, when describing the philosophy of Plato, affirms, that "he maintained three independent principles in nature, namely, *God, Matter,* and *Ideas;*" but that conclusion is not borne out by the writings of Plato, though it may have been subsequently admitted into the Academic creed. It seems probable that the language of Plato, when freed from rhetorical ornament, meant nothing more than that there existed from eternity, in the Divine Mind, a notion or distinct conception of every thing which was to exist in time—a theory not unlike that for which Malebranche has contended in later ages. Still it must be admitted, that if this be all that was intended to be included in the ideal world of Plato, it is difficult to reconcile with this opinion other passages, in which ideas are represented, not only as objects of science, but the efficient and physical cause of all substances. The idea of resemblance between two ideas, for example, is said to be the cause of that resemblance; on which account ideas are sometimes expressly called by this philosopher *essences;* and he affirms that they always remain the same, without beginning or end. "The *Reason* of God," says Plato, in his *Timæus,* "comprehends the exemplars of all future existences, and is the primary cause of their being." The conclusion drawn by this speculative philosopher from the preceding premises, was, that the objects of sense were fleeting shadows, and ideas the only permanent and enduring substances, worthy the contemplation of intellectual and rational beings.

V. THE HUMAN SOUL.

152. From some of the dialogues of Plato, and from the writings of the most celebrated Academic philosophers, it may be gathered that the Platonists considered the soul of man as derived from the Supreme Divinity, or rather, as an emanation from the Divine Nature. This emanation was not supposed to be immediate, but transmitted through the agency of the *Demiurgos*, or Creator, and by the intervention of the "*Anima Mundi.*" This soul of the world being itself in some degree debased by earthly admixtures, the human soul, which was derived from it, receded still farther from the perfection of the First Intelligence. Upon this principle, the Platonic philosophers attempted to account for the origin of moral evil, and the existence of misery and suffering, since they taught, that "when God formed the universe, he separated from the soul of the world, inferior souls, which, while separated from matter, were perfect and happy, but became debased, when attached to and confined in material vehicles. It has been questioned by some, whether the immateriality of the soul formed part of the Platonic creed. It is, however, probable that Plato believed the soul of man to be partly material and partly spiritual; the former of these properties being necessary to

its converse with sensible objects, and the latter rendering it capable of divine contemplation and intercourse with the Deity. In other parts of the writings of Plato, the soul of man is represented as consisting of three parts; one the seat of intelligence, another of passion or feeling, and the third of appetite; to each of these, appropriate places were assigned in the human body as their fixed residence. With respect to the duration of the soul of man, it is unquestionable that the Platonists strenuously contended for its immortality. Numerous arguments are adduced by Plato, in his dialogue, entitled "PHÆDO," in support of this opinion, some of which are drawn from the analogy of nature, and others from speculative and abstract reasonings. Sometimes it is inferred from the alternations of sleeping and waking, or the ceaseless revolution of the seasons; and sometimes it is argued from the supposed nature and properties of the human soul, its powers of reminiscence, its capacity of knowledge and indefinite improvement, and its communication of life and motion to the material vehicle which it inhabits. On these, and many similar grounds, it was maintained, that the soul, though it may pass through many changes, and inhabit different bodies, cannot cease to exist.

VI. DÆMONS, OR SUBORDINATE DIVINITIES.

153. Plato, in common with almost all the philosophers of Greece who were not avowed atheists, taught that there were certain orders of created intelligences superior to man, but subordinate to the

Great First Cause. To these he gave the name of Dæmons, which he conceived to be, for the most part, struck off by the power of the Demiurgos or Creator, from the "soul of the world," though some of yet higher rank were supposed to be co-ordinate with him. To these subordinate deities were assigned the charge both of forming and preserving inferior creatures, as well as of superintending the several parts of the material universe; some ruling the stars; others inhabiting and regulating the air; while those of inferior dignity were attached to the earth, and presided over its inhabitants. This theory seems to have been borrowed from the Pythagorean philosophers, one of whom had asserted long before, that "the Ruler of all assigned the inspection of human affairs to dæmons, and committed to them the government of the world."

SECTION III.

ON THE METAPHYSICAL SYSTEM OF ARISTOTLE AND THE PERIPATETICS.

154. THE metaphysics of Aristotle and his disciples are characterized by the same ingenuity of invention and artificial obscurity, which distinguish his dialectics. So highly did that great philosopher estimate intellectual science, as emphatically to style it the *first* or *chief philosophy;* intimating not only that, in his opinion, all other objects of human speculation were vain and trifling, but that this

comprehended in itself the sum of human knowledge. In presenting a sketch of the metaphysical opinions of the Peripatetic philosophers, it will be most convenient to follow the arrangement of topics suggested by its illustrious founder. These are, *being,* abstractedly considered—*substances* or essences—the *divine mind*—the *human mind*—and *animal life.* In this order, the principal metaphysical dogmas of Aristotle are discussed in those of his writings which still remain, and the same classification has usually been adopted by his commentators both in ancient and modern times.

I. BEING, IN GENERAL.

155. The fundamental axiom of the Peripatetic school on this subject was, that "it is impossible that the same thing should be and not be at the same time, in the same subject, and in the same respect." On this primary and self-evident truth, Aristotle professed to found all his reasonings and deductions on metaphysical subjects, and by its means to demonstrate all the phænomena both of matter and mind. This basis having been laid, he proceeded to the enumeration of the several kinds of existences, and the different modifications of Being. These were considered, 1. With respect to their origin, as either self-existent or accidental; the former applying alone to the Deity, the latter to all created substances. 2. With respect to their nature, as either notional or real—notional, as conceived in the mind, and real, as existing in nature. The former of these are again subdivided into true, or that which corresponds with the real nature of things; and false, when the conception and reality differ. 3. With respect to their several modes, beings are contemplated as existing either in power or in act, that is, as the subjects either of active or of passive power. By active power was intended the principle of motion or change, and by passive, the capacity for motion or susceptibility of change in any subject, on which such active power is exerted. 4. Considered with relation to number, Being includes the properties of unity, identity, equality, resemblance, and the like. 5. And, finally, the genera and species of beings are adverted to—terms employed by this celebrated dialectician to distinguish their primary and essential, from their subordinate and accidental qualities.

II. SUBSTANCES.

156. Substances, according to the Peripatetic philosophers, are of three kinds—primary matter, form, and essence, together with the compounds of each. Corresponding to this three-fold modification of substances, three properties or qualities are enumerated—immovable, incorruptible, and perishable. The first of these belongs alone to the Great Cause of all things, whom Aristotle describes as the "First Mover, himself unmoved;" the second, to heaven, and spiritual existences, whether superhuman or divine; the third, to animal bodies of every kind and degree. To the *Primum Mobile*, or First Mover, (whatever that term might denote, whether God or Nature, or an unknown and incomprehensible

something, of which no distinct conception was entertained,) were attributed eternity, infinity, immutability, indivisibility, and spirituality. This abstract notion of a Primary Mover, Aristotle seems to have derived from his theory respecting motion in general, which he considered as proceeding from the perfect and eternal revolution of the heavens. But in order to avoid the absurdity of an infinite series of effects without a cause, he was compelled to admit into his system, a "*Primary Mover*," who from eternity acted upon the celestial sphere, and gave it its first impulse, just as the human soul acts upon, and communicates motion to, the several organs and members of the body. All other substances, whether incorruptible or corruptible in their nature—whether eternal or temporary in their duration—are yet far inferior to this Great Primary Cause of Motion, by whose perpetual agency on matter, bodies undergo all their varieties of form and external modification, and are continually dissolved and reproduced in endless continuity.

III. THE DEITY.

157. From the above statement, it will be evident, that Aristotle and his followers are not to be classed with the atheistical philosophers of antiquity, though their speculations on the subject of the Divine existence and attributes were far less intelligible and rational than those of the Platonic school. God is represented, in the Peripatetic system, as a Being distinct from the world and matter, but imparting to both their energy and motion; as

superior, in a vast and incomprehensible degree, to all other intelligent natures, but not the cause of their existence; for, conceiving matter to be eternal, the work of creation, or the primary production of the material universe, was not attributed to the Deity, but solely that of giving motion to substances eternally existing, like the main-spring of a machine, which does not produce the mechanism, but simply puts it in motion. In producing motion, the Deity was supposed to act not voluntarily, but necessarily; not for the sake of other beings, but for his own pleasure. Eternally employed in the contemplation of his own nature, he observes nothing, he cares for nothing beyond himself. Residing in the first sphere, he possesses, according to the Peripatetic system, neither immensity nor omnipresence. Far removed from the inferior parts of the universe, he is not even the spectator of passing events, and therefore can neither be an object of veneration or worship. He is indeed described as intelligent, immaterial, and eternal: but those attributes seem to have answered no more important purpose than that of giving the first impulse to the mechanism of nature, and originating the motions of the celestial bodies.

IV. THE HUMAN MIND.

158. On this subject, the following summary of the principal tenets of the Peripatetic philosophers has been given, which will be found to have been chiefly gathered from Aristotle's writings. "The soul is the first principle of action in an organized

body, possessing life *potentially*. The soul does not move itself; for whatever moves, is moved by some other moving power. It is not a rare or subtile body, composed of elements; for then it could not have perception, any more than the elements which compose it. It has three faculties—the nutritive, the sensitive, and the rational; the superior of these comprehending the inferior. The *nutritive* faculty of the soul, is that by which animal life is produced and preserved; the *sensitive*, that by which we perceive and feel, through the intervention of the bodily organs. The senses are of two kinds; external, by which objects are perceived; and internal, by which their properties and relations are known, and their agreement or difference observed. Perception differs from intellect, inasmuch as the former is common to all animals, but the latter belongs only to a few. To the intellectual part of the human soul belong fancy, memory, reminiscence, and other similar properties and powers. Fancy denotes the perception itself, accompanied with different sensations, according to the object perceived. Memory is the permanent impression left behind, after the object is withdrawn, and succeeds to fancy. Reminiscence is the power by which it is recalled, and the lost impression renewed. The *rational* faculty of the soul is that by which it understands, compares, and judges. It is of two kinds—active and passive. By its passive quality, it is rendered capable of receiving impressions, or the forms of things; but its active energy is the efficient cause of all knowledge. The knowledge thus acquired may be either speculative, as conversant with abstract truths, or practical, as influencing the will and affections, and productive of moral good or evil.

V. ANIMAL LIFE.

159. A distinction was made by the Peripatetics between the principle of life and of intelligence, or the *soul* and *spirit*. Animal life was supposed to be the result of an union between the nutritive soul and animal heat: so long as this union lasts, life is preserved; when a separation takes place between them, from whatever cause, death follows. As far as any distinct conception can be formed of the nature and origin of the vital principle, according to the Peripatetic system, (in which the subject is treated with the utmost obscurity,) Aristotle appears to have taught, that it is a mysterious energy or power, emanating from the Supreme Intelligence, and externally transmitted into the human body; by which all its movements and actions are regulated, so long as this animating principle continues inherent in the human frame. But there is no reason to suppose that this philosopher, like Plato, taught or even conjectured the immortality of the soul. It seems more probable that he maintained the total and final extinction of animal life at death, though not of *being;* for all substance, in whatever form it may have existed, was believed to be eternal and indestructible.

SECTION IV.

ON THE METAPHYSICAL SPECULATIONS OF ZENO AND THE STOICS.

160. THE celebrity of the Stoic sect, both while the Grecian states retained their independence, and under the Roman government, renders it important that the tenets of its founder and most distinguished members, on all subjects, but especially on those which relate to the philosophy of mind, should be attentively reviewed. Every facility, which can be desired for this purpose, is afforded by the numerous writings of antiquity which still exist, in which that system is advocated and explained. The writings of Laertius, Cicero, Seneca, Plutarch, and Epictetus, with many others which might be enumerated, furnish ample materials, from which all requisite information may be obtained relative to a sect which perhaps includes a greater number of illustrious names than any other known to the pagan world. In some of those valuable remains of antiquity to which we have just referred, the Stoical system will be found developed in all its bearings, and its distinguishing doctrines are defended with much ingenuity and subtilty of reasoning. The following summary will comprehend its more prominent features, from which it will appear that it emanated rather from the Pythagorean than the Platonic school, though in many important respects it differs materially from both.

161. (1.) Concerning *Nature*, its origin, and mode of production, Zeno and his followers taught, that there existed from eternity, a dark and confused chaos, containing the primary elements of all beings, which, at different periods, emerged into variable forms, and from which the material universe was produced. But by whom or by what, as its primary cause, this arrangement was effected,—whether by an intelligent agent, or whether by a mysterious something which they termed Destiny or Fate, or whether by mere accident,—the wisest of these boasted philosophers were wholly unable to determine. Some indeed of the more *devotional* writers of this sect, (if the term may be applied to pagan philosophers,) speak of God, as the great active principle, pervading the universe, and diffused through all its parts; but at other times, the origin of all things seems to be attributed to blind fate, or necessity; and sometimes to the mechanical influence of an ethereal fire, which imparted life to all created substances. "What is Nature," says Seneca, "but God?—the divine Logos, or Reason—inherent in the whole universe, and in all its parts,—or you may call him, the Author of all things." Diogenes Laertius, in describing this part of the Stoical system, asserts, that "God and the world,—the artist and his work—were comprehended under the term Nature, because they considered the Deity as mixed or diffused through the world. Sometimes they called that Nature, which contains the world, and sometimes that which generates and produces all terrestrial substances." In general it will be

found, that the rational, efficient, and active principle, from which the universe, and all that it contains, derived their existence, is promiscuously termed, by Stoical writers, "Nature, God, Zeus, or Jupiter, Reason, and Fate."

162. (2.) The *Universe* was supposed by the Stoic philosophers to contain two principles, denominated *active* and *passive*. The former, ingenerate, incorruptible, and intelligent; the latter, inert, mutable, and subject to decay. They do not appear to have attached distinctly the idea of *spirit* to the active principle of the universe, though they assert that it is void of form, and destitute of the ordinary properties of matter. It was supposed to be in its nature corporeal, a kind of celestial fire, so refined and subtilized, so free from all the grosser qualities of bodies in general, that it might properly be termed immaterial and spiritual. The passive principle denoted, gross, inert matter, destitute in itself of all qualities, but capable of receiving any which might be produced upon it; incapable of motion, but subject to the action of any external efficient cause. These two principles composing the whole universe, it necessarily followed, that the Stoics agreed with the Platonic philosophers in maintaining the notion of an "*Anima Mundi*," or divine principle of life and motion, diffused through the whole system of nature. To this universal and operative principle were attributed all the sentient and intelligent properties of mind. But however refined may have been the speculations of the philosophers of this sect, respecting the great intel-

ligent Cause of all things, when they attempted to describe his nature, attributes, residence, and agency, they were involved in the grossest absurdities. They conceived of him, as dwelling in the super-celestial regions, in the form of ethereal fire—as impelled by a stern and inevitable fate, over which he had no controul — as borne along, in common with all inferior existences, by the irresistible current of necessary causes and effects—and, in a word, as in no rational sense whatever, a voluntary or moral agent, but merely a machine, controlled by circumstances, and governed by invincible destiny.

163. (3.) Respecting *Man*, the Stoic philosophers taught, that he is an image or exact representation of the world; that in him also there are two principles, *active* and *passive;* or, in other words, body and mind. The mind of man was supposed to be an emanation, or spark of the ethereal fire—a portion of that reason or divine intelligence by which all nature is animated. But while they asserted that the human soul partook of the nature of the gods, they considered it as restricted in its energies, deteriorated and debased by its combination with grosser matter. Thus Seneca writes concerning man; "Why should you not believe that there is something divine in him, who is indeed *part of God*—that *whole* in which we are contained is one, and that one is God; we being his companions and his members." Epictetus, in stronger language, affirms, that "the souls of men have the nearest relation to God, as being *parts* or *fragments* of Him, separated and torn from his substance."

"All men," says Cleanthes, "proceed from one, and will be resolved into one." The powers or faculties of man were said to be eight, viz. the five senses, the productive or generative faculty, the power of speech, and the ruling power, denominated reason. To each of these were assigned their several stations and their respective offices in the human economy. Widely different opinions were entertained respecting the duration of the human soul. Though none maintained its immortality, all agreed in asserting its existence after death. Cleanthes taught, that all souls would continue to exist, till the final conflagration;—Chrysippus and Seneca, that this privilege would be granted alone to the virtuous and the good. Epictetus and Antoninus held, that as soon as the soul is released from the body, it returns to the soul of the world, or is lost in the universal principle of fire; while others maintained, that it continued for ages immured, till the general destruction of the universe. Some philosophers of this sect seem to have leaned to the Pythagorean notion of *transmigration*, and others to the oriental scheme of *re-absorption* in the Divinity.

164. (4.) In connexion with the preceding speculations respecting the nature and origin of Man, it was believed that there were portions of the ethereal fire distributed through all parts of the universe, and giving existence to an innumerable multitude of beings superior to man, though far inferior to the Supreme Intelligence. These were denominated *gods* or *dæmons,* who were divided into two classes, superior and inferior: the former inhabiting the sun and stars, which they considered as animated substances; the latter were human souls, in a separate state of existence, or heroes. To none of these, however, was given the privilege of immortality. "The Stoics taught," says Plutarch, "that the heavens, the earth, the air, and the sea, are full of gods: but that none of them are immortal, except Jupiter, to whom all the rest will at length return, and in whom they will lose their separate existence.".

165. (5.) The Stoics, in common with all the other ancient philosophers, were much perplexed with the great question relative to the *origin of evil.* Some concurred with the Platonists in ascribing it to the deteriorating influence of matter, which defeated the original design of the great Artificer of Nature. Others, perceiving that this hypothesis was at variance with their fundamental doctrine relative to the divinity of nature, and the universal diffusion of the Deity, had recourse to *fate,* as furnishing the only rational solution of the difficulty, by which the actions both of gods and men were said to be controlled. Thus, when Chrysippus was asked, "whether diseases were to be attributed to the will of the gods," he answered, that "it was neither the intention of nature that such calamities should take place, nor was it according to the will of the Supreme Divinity, but that destiny deranged his wise and benevolent plan, and rendered these evils necessary and inevitable.

166. (6.) But the most curious part of the Stoical

system, which seems to have been chiefly derived from the oriental philosophers, and which they, in their turn, probably derived through the medium of traditional revelation, was, their belief in the *final dissolution of the universe by fire.* To this, there are innumerable allusions in the writings of the ancient philosophers of this sect. The following passage, contained in one of Seneca's epistles, is one of the most express. " The time will come," says that celebrated philosopher, " when the whole world will be consumed, that it may be again renewed—when the powers of nature will be turned against herself—when stars will rush on stars, and the material world which now appears resplendent with beauty and harmony, will be destroyed in one general conflagration. In this grand catastrophe of nature, all animated beings, (excepting alone the Universal Intelligence,) men, heroes, dæmons, and gods, shall perish together." This catastrophe was, however, not supposed to terminate in the annihilation of matter, but merely in reducing it to its pristine chaotic state. Then all the present frame of nature will undergo a complete change—all material forms will be lost in one chaotic mass—all animated nature reunited to the Deity—and nature will again exist in its original form, as one whole, consisting of God and matter. From this chaotic state, it is again to emerge by the energy of the great active Principle; and gods and men and all material forms are to be renewed, and dissolved, and renewed, in an eternal succession. Each of these grand revolutions, extending from the reproduction to the dissolution of the universe, was termed by the Stoic philosophers—the *great year.*—Vide *Enfield's Hist. of Philosophy,* Vol. I. p. 338—341.

SECTION V.

SKETCH OF THE ECLECTIC SECT, AND SUMMARY OF THEIR METAPHYSICAL TENETS.

167. AFTER the decline of literature had taken place throughout the Roman Empire, about the commencement of the third century, there sprang up at Alexandria in Egypt, a new sect of philosophers, who assumed to themselves the name of *Eclectics,* because they professed to acknowledge none of the ancients as their masters, but to select, from all the metaphysical and moral systems of former ages, those principles which were most consonant to reason and truth. The philosophy of Plato formed the basis of this new system, and the earliest Eclectics were the professed admirers and disciples of that great philosopher, on which account they were sometimes called *Later Platonists;* but in many respects, they differed both from the founder and supporters of the Academic sects. With the distinguishing tenets of Plato and his followers, were blended many others derived from the Peripatetic, the Stoic, and the Oriental systems, to which were added some absurd and almost unintelligible speculations of their own. The design of effecting a coalition between the ancient systems, clearing

away the superfluities of each, terminating the controversies which they had occasioned, and forming out of them all a well-digested and harmonious system of philosophy, was in itself excellent: but the history of this sect abundantly proves, that its votaries utterly failed in the execution of this arduous task, and that, "by combining systems originally distinct from each other, by personifying abstract conceptions, by inventing strange fictions concerning the Supreme Being and subordinate divinities, and by raising upon these fictions a baseless fabric of enthusiasm and fanaticism, they introduced infinite confusion into philosophy, and fatally obstructed, instead of promoting the progress of useful knowledge."

168. This sect was founded by *Potamo,* an avowed Platonist, who flourished towards the close of the second century. It was consolidated and extended by *Ammonius Sacca,* who had received a Christian education under Athenagoras, Pantœnus, and Clemens of Alexandria, and has been classed by some with the Christian philosophers of that age. His labours, however, were chiefly directed to the amalgamation of Christian doctrines with the philosophy of Plato. To him succeeded, in the Alexandrian school, *Herennius, Origen, Longinus,* and *Plotinus.* The latter of these, who was a native of Lycopolis in Egypt, and one of the disciples of Ammonius, occupies a distinguished place among the Eclectic philosophy; and indeed to his personal instructions and writings, that sect chiefly owes its celebrity. His numerous works on metaphysics, dialectics, and ethics, furnish the fullest and most authentic information of their peculiar tenets; and his active zeal propagated the system in many distant countries. Next to Plotinus, the two most celebrated advocates of the Eclectic philosophy were *Porphyry* and *Jamblichus*. Porphyry was a native of Tyre, educated first at Cæsarea, under Origen, then at Athens, under Longinus, and finally at Rome, under Plotinus. He is best known to posterity as one of the most zealous supporters of the Pagan theology, and a bitter enemy of Christianity. His principal writings, which have survived the wreck of time, are, "his Life of Pythagoras, Illustrations of Homer, Commentaries on Aristotle's Logic, and Life of Plotinus." These are characterized by much erudition and a species of splendid eloquence, which indicated a vitiated taste; as well as by the absurdities and mysticism of the Eclectic school. Jamblichus was a native of Chalcis, and pupil of Porphyry, who flourished at the commencement of the fourth century. He was inferior to his preceptor in eloquence, but of equal learning and industry. He wrote on a great variety of subjects, the chief of which were historical, philosophical, and mathematical treatises. But the most curious, and by far the most valuable of his remains, is, his celebrated work on the "Mysteries of the Egyptians, Chaldæans, and Assyrians," in which are found references to and extracts from oriental books which have long since perished. In addition to those enumerated above, who may be considered as the founders or principal supporters of the Eclectic system, there were not a few of reputed learning, who, though not philosophers by profession, embraced and advocated the Platonic philosophy, as taught in the Alexandrian school. Among these were, Julian, the Roman Emperor, Eusebius of Myndus, Hierocles, Proclus, Isidore of Gaza, Macrobius, and Ammianus Marcellinus, each of whom wrote in defence of the doctrines of Platonism.

169. It is scarcely possible to give in an abridged form a distinct conception of the metaphysics of this school. The following outline, collected chiefly from the works of Plotinus, may suffice for our present purpose. The opinions of the Eclectic philosophers respecting

I. THE DEITY.

"The *First Principle* of the universe is not the universe, but above all, and the power of all, without which nothing could be; which, though the fountain of being, is itself incapable of division or increase. This First Principle, the cause of intellectual life, the source of essence and being, is simple, and having no place, has neither motion nor rest. It is infinite, not as being immense, but as it is one; and has nothing by which it can be limited. Because that from which all things proceed can permit nothing to exist better than itself, it is the best of all beings. It is essential good, most fair and beautiful; and because it is in itself lovely, and the author of all that is lovely, it is the beginning and end of beauty. No attribute is to be ascribed to this First Principle in the same sense in which it is ascribed to other beings, but in a manner wholly inexplicable. Its nature is rather to be comprehended by profound contemplation, than by any act of the understanding."

II. MIND, SOUL, AND MATTER.

"From this *First Principle* proceeds mind or intellect, and soul, or the active principle. The primary *Essential Good* is the centre; mind, the light emerging from it, and remaining fixed; soul, the motion of the light thus emanating; and body, the opaque substance illuminated by the soul. The second principle, mind, is necessarily united to its source, and is the image of God, bearing such a resemblance to him as light bears to the sun. It is produced by the energy of the first principle, and is the excited power of vision, reflection, or intelligence. This second principle being produced, its energy produces within itself the fair universe of ideas, or intelligible natures, whence it comprehends a plenitude of all things as essential principles, before they exist as material substances.

"From the emanative energy of *mind* is produced *soul*, or the active principle of life. This divine principle is the fountain whence all life is derived. It subsists, as well as intellect, within the divine essence, and is therefore *supramundane*. This is the immediate source of the principle which animates or resides in the world, and which is diffused in various portions through all animated nature.

"Matter is the receptacle and subject of forms, but has in itself neither figure, quality, magnitude, nor place, and can therefore only be defined negatively. Nevertheless it is not a mere name, but truly exists as the basis of qualities. Matter exists potentially, and has so existed from eternity—bodies actually, with their peculiar characters, forms, modes, and periods of existence."

III. THE WORLD.

"There never was a time when matter and form existed separately, or when the universe was not animated. To suppose the formation of the universe the effect of chance, is absurd. The world is to be conceived of as having always existed, and mind as prior to it; not in the order of time, but of nature; and therefore as the eternal and necessary cause, both formal and efficient, of its existence. The sensible world is produced after the pattern of the intelligible, by the energy of mind pouring forth some of its own nature upon matter, and hereby giving it the first unconscious principle of motion and form. The world contains superior and inferior regions; the former of which are inhabited by subordinate divinities, genii, heroes, &c.; the latter, by men and inferior animals: because the world includes every thing within itself, so that there is nothing into which it can be changed, nor any external force by which it can be dispersed or annihilated, it must be perpetual in its duration."

IV. THE HUMAN SOUL.

"The soul of man," according to the Eclectic system, "is derived from the supramundane soul, or first principle of life, and is, in this respect, sister to the soul of the world. Souls are not in the body as their place, nor as their receptacle, nor as their subject, nor as part of a whole, nor as form united to matter, but simply as the animating principle; for it is in this respect only that we are conscious of the presence of the soul. The power of the soul is diffused through every part of the body; and though it be said to reside in its chief instrument—the brain, it is incorporeal, and exists entirely every where within the sphere of its energy. Partaking of the nature of real being, it is immutable. It is the principle of motion, moving itself, and communicating motion to bodies. The vices and sufferings of the soul are wholly derived from its union with the body."

V. A FUTURE STATE.

"Souls, in the periodical revolutions of nature, separate themselves from the great first principle of life, and descend into the lower regions of the world. In their passage, they attract to themselves an ethereal vehicle, and at last sink into animal bodies, as into a cavern or sepulchre. But when, by the power of reminiscence, they again turn themselves to the contemplation of intelligible and divine natures, they regain their freedom. For though the Deity is not known by sense or reasoning, yet by a kind of intuition, superior to all science and wisdom, the soul can see God in his real nature. This vision of God having been enjoyed, it will lament its imprisonment in the body, and rejoice in the prospect of that emancipation which is effected at death, when it is permitted to return to the Divine Nature whence it proceeded. After death, the souls of men pass into other animals, or ascend into superior regions, or are converted into demigods, and beings of a higher order, according to their present state of deplement or of purification."

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170. Such were the principal tenets of the Ammonian school of philosophers on metaphysical subjects; from which it will appear, that, though some light was derived from the Jewish and Christian revelations, their system was chiefly made up of Platonism and Hindùism, rendered still more obscure and visionary by a thousand subtle distinctions and vain imaginations of their own invention. The preceding summary of the metaphysical opinions of the Eclectic philosophers, has been taken from the more extended view of the system, which the learned Brucker has introduced into his "History of Philosophy," and which he appears to have collected with much fidelity from the works of the principal writers of that school, particularly those of Plotinus and Jamblichus. Brief as is the sketch

which has been given, it is evident that these far-famed philosophers frequently lost themselves in abstractions, and veiled their ignorance in a cloud of terms, to which neither they nor their readers could attach any intelligible ideas; that, with a few important truths, were blended multitudes of gross and palpable errors; and that, in defiance alike of the sober dictates of reason, and the authority of Revelation, with which they were or might have been acquainted, they gave themselves up to vain imaginations; thus justifying the testimony borne respecting them by an inspired Apostle, " esteeming themselves wise, they became fools."

CHAPTER VII.

ANCIENT ETHICS.

SECTION I.

ON THE ORIGIN AND PROGRESS OF ETHICAL SCIENCE AMONG THE PHILOSOPHERS OF GREECE AND ROME.

171. ALTHOUGH many ages elapsed from the first civilization of the Grecian colonies, before the moral maxims, inculcated by the earlier philosophers, and to which they owed much of their celebrity, assumed a systematic form; yet never has there been a period in which the moral relations of mankind, both towards the Supreme Being, and those of their own species, have not engaged the attention of the intelligent and the wise. Whence those notions of morality were derived in the infancy of society; whether from a primary divine revelation, handed down by tradition; or whether from the deductions of human reason, or whether by intuition, it is not our present business to inquire. Whatever opinion may be formed of the source or medium of communication, none can deny the fact itself. It is sufficient for the present to state, as a matter of history, confirmed by all the records of antiquity, that such elements of moral science are known to have existed among all nations, and in every stage of civilization, from

the rudest and most barbarous, to the highest degrees of intellectual refinement. Long before any considerable advances were made in physical science, it is well known that many moral apologues were invented, and many ethical maxims promulgated for the instruction of mankind. An allusion has already been made to several Persian, Chinese, Hindoo, and Arabian philosophers, as well as to those who, by way of eminence, were designated "*the Wise Men of Greece*," who, if they have any claim whatever to the title of philosophers, must evidently belong to the ethical class.

172. The first among the Greeks who made any approach towards the arrangement of a system of ethics, was the celebrated philosopher of Samos, to whom frequent reference has been already made, as the founder of the Italic sect, and who was confessedly one of the greatest men of antiquity. The moral instructions of Pythagoras, it is true, like those of his predecessors, were not drawn up in a didactic form. They consisted rather of aphorisms and sententious maxims, insulated from each other, and having little pretension to order or arrangement; yet they were classed under general heads, and formed into a kind of moral system. Whether the honour of this classification belongs to Pythagoras himself, or was borrowed by him from some unknown oriental philosopher, has been questioned; but it is certain that *he* was the first among the Greeks who attempted to promulgate the outlines of a moral system, in which the personal and social virtues were arranged in their

natural order. This is affirmed on the high authority of Aristotle, who asserts, that the philosopher of Samos was the first of the ancients who undertook to treat distinctly of the nature of virtue, ı he divided into two great branches, public private; the former comprehending all those s which men owe to each other, and the latter which they owe to themselves. Under the of private virtues, he enumerated "institution lucation, silence, abstinence from animal food, ude, temperance, and prudence;" concerning of which many didactic rules were given to isciples. Among the public or social virtues enumerated "conversation, friendship, religi worship, reverence for the dead, and legis ı." Two methods of conveying this moral action were adopted; one, that of proverbial ms, short, and easy of remembrance; the other, of mystical symbols, some of which were ex ıgly curious, and only to be understood by the ted.*

3. The next important æra in the history of ıt ethics, was that in which Socrates flourished, tands pre-eminent among the philosophers of this department. He was the first of the pagan philosophers, who laid down, as the basis of all his moral instruction, a regard to the authority of the Supreme Legislator. In his lectures and discourses,

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* A full account of these, collected chiefly from the writings of Diogenes Laertius, is given by Stanley, in his History of Philosophers.

(as far as they can be collected from the writings of Plato and Xenophon,) he seems to have kept in view one great object, namely, to impress the minds of his disciples with sublime conceptions of the character and moral administration of the Deity, and on this ground to rest the obligation of intelligent and accountable beings to practise every private and social virtue. The principles of virtuous conduct, he contended, were in reality the *laws of God*, which are alike binding on all mankind, and can never be violated with impunity. The chief arguments by which this position was supported, were derived from the instances of moral retribution which continually occur both in the history of nations and individuals. As far as the opinions of this celebrated moral philosopher, on the much agitated question respecting the nature and grounds of moral obligation, can be collected from the testimony of his disciples, (for Socrates himself left no writings behind him,) they seem to have amounted to this, that "there is in every man a *conscience*, or what modern ethical writers have termed, a *moral sense*, which clearly points out to him the distinction between right and wrong, and enables him in every given case to discriminate virtue from vice; but that the will of the Supreme Legislator, as made known in his laws engraven on the conscience, constitutes the sole *ground* of duty and moral obligation."

174. The philosophical system of Socrates (if system it may be called) was practical rather than theoretical or speculative. Its principal divisions

have been thus arranged. "Man may either be considered as an *individual*, or as the *head of a family*, or as a *member of the commonwealth*. Hence arise the three great branches of moral science, comprehended under the general terms, *ethics*, *œconomics*, and *politics*. Each of these has its appropriate virtues and vices, which it is the business of true philosophy to discover and make known to mankind." It does not appear that any more minute classification of personal, relative, or social virtues was attempted by this philosopher; but a great variety of excellent maxims in morality are attributed to him on the several topics of Piety, Obedience to superiors, Constancy, Temperance, Liberality, Patience, Magnanimity, Truth, Justice, Friendship, Patriotism, with many others. The form in which these moral aphorisms have been preserved, is that of sententious answers said to have been given to questions proposed by his disciples and friends. From this peculiarity in his mode of communicating didactic instruction, all subsequent philosophers, who had recourse to dialogue, were said to have adopted the Socratic method; which, however suited to moral and practical subjects, was a most inappropriate medium by which to carry on abstract and metaphysical reasonings. A powerful impulse was given to moral science by the personal instructions of Socrates, the effects of which were apparent long after his death, especially in the Academic sects. Many important questions connected with this department of human knowledge began to be agitated and publicly discussed in the schools, of which the following are specimens. "What is the criterion of virtue? whence is it derived? and what will be its results? What is good? What the distinction between natural and moral good? What the chief good? Wherein does happiness consist? Is pain to be accounted a good or an evil?" To these and many similar ethical questions, widely different answers were given by the *Platonists,* the *Peripatetics,* the *Epicureans,* and the *Stoics,* the distinguishing features of whose respective moral systems will be briefly adverted to in the following sections.

SECTION II.

ON THE ETHICS OF PLATO AND THE ACADEMICS.

175. IT does not appear, from the writings of Plato, that he formed any distinct ethical system, though many of his dialogues treat of moral subjects. These, it is probable, were chiefly derived from the didactic instructions of his illustrious preceptor, but greatly modified and obscured by the metaphysical speculations in which he so freely indulged. The most important topics discussed in his ethical writings relate to the chief good, the nature of virtue, the moral influence of the passions, and the social duties of life.

The Chief Good consists in the contemplation of *mind,* a term used to express the Supreme Intelligence. All the subordinate degrees of goodness are only such as they approximate to the chief good. That faculty of our nature by which this resemblance is to be attained is Reason; and its several modifications are the fair, the venerable, the amiable, the proportionate, and the happy. Of those things which men are accustomed to call good, such as beauty, strength, riches, and the like, none are such any farther than they lead to the practice of virtue. These are termed, by way of distinction, mortal good, on account of their imperfect nature and transitory duration; but beatitude, or happiness, which was considered as the inseparable companion of virtue, is a divine and immortal good, worthy of the pursuit of intelligent beings, and producing a resemblance to the gods. To this chief good, the souls of philosophers are elevated after death; they are replenished with these inexhaustible treasures; they are admitted to divine entertainments; they range at large amidst the boundless regions of truth, and look down with contempt on those who are satisfied with earthly shadows and unreal good. He alone who has attained to the knowledge of the first good, is happy; and the end of this knowledge is to render man as like the Great Intelligence as human nature is capable of becoming.

176. *Virtue,* according to the definition given by Plato, consists in resemblance to the Deity. It is the brightest perfection of human nature. Its influence extends to the whole character, and it constitutes the brightest ornament of man. Some of the virtues exert their influence on the rational, others on the animal, and others on the sensitive

parts of our nature: of the former, the cardinal virtue is *prudence,* by which was meant, the discrimination of moral good and evil; of the second, *temperance,* or the due regulation of our desires and appetites; and of the third, *fortitude,* or the subjection of our feelings to the command of reason and the dictates of conscience. From the combined influence and operation of these, arises a fourth cardinal virtue, *justice,* which is chiefly exercised in the social relations of life. Beside this more general classification of virtue, many subordinate distinctions were made by the Platonists, such as perfect and imperfect, necessary and voluntary, personal and relative, with many others. But the most defective and dangerous part of the moral system of Plato was, that in which he taught, that all vice is involuntary, and consequently to be punished not so much on its own account, as because of the evil it brings on others; while on the other hand, he maintained that virtue is to be pursued and practised for its own sake, and not merely because of the happiness it yields.

177. The *Passions* were defined to be motions of the soul excited by some apparent good or evil, originating in the irrational parts of our nature, but capable of being moderated and subdued by reason. All the passions are reduced to two simple elements, *pleasure* and *pain,* or *joy* and *grief;* — desire, fear, hope, and all other mental affections, are but modifications of these. They are excited in us by nature, and form a part of our constitution; but the degree of their excitement depends on the circumstances of the

individual who is affected by them. Some of the passions are mild---such as pity, mercy, modesty, and contentment; others violent—as anger, terror, love, and hatred; while some partake of a mixed character. The moderate indulgence of the passions is virtuous—their excess alone is vicious.

178. The *social virtues* are chiefly delineated in connexion with political maxims, and the rules laid down for the administration of a perfect commonwealth. Friendship consists, according to the Platonic philosophy, in reciprocal benevolence. It is that disposition which prompts its possessor to feel as solicitous for the happiness of another, as his own. The good-will of parents to their children, and the affection of kindred to each other, are but different exhibitions of this social virtue. Love, considered not as a passion but a branch of social duty, was contemplated as of three kinds, namely, "*honest, dishonest,* and *mean.*" The honest, or honourable, contemplates only the mind and its virtuous qualities; the dishonourable aims only at sensual indulgence, and is absolutely brutish; the mean regards the beauty both of the soul and body, and therefore occupies a *mean* place between the two former. In society, as in the human soul, there are three parts; *keepers, defenders,* and *artificers:* the first includes chiefs and rulers, whose duty it is to counsel, direct, and govern, answering to the rational part of the human soul; the second, warriors, whose duty it is to defend the commonwealth by their military prowess, and therefore resemble the active powers or passions of the soul; the

third, those who cultivate the arts, or are employed in the ordinary occupations of life; and these are compared to the animal appetites, or the irrational part of the soul. The perfection of government was supposed to consist in each of these performing their appropriate offices and relative duties.

179. From the preceding sketch it will be evident that the ethics of the Platonic school were partly derived from the maxims of Pythagoras, and partly from the moral lessons of Socrates, digested into a more regular system, and tinged with the splendid colouring of Plato's metaphysical genius. Dr. Enfield justly remarks, that though many just and sublime sentiments on morals are found in the writings of Plato, his ethical doctrine is in some particulars defective, and in others, extravagant and absurd. The fanciful notions which he entertained concerning the Divine Nature, the world of ideas, and matter, seem to have given a romantic and enthusiastic turn to his conceptions on morals; a defect which may be in part ascribed to his connexion with the Pythagorean school, but which was, perhaps, chiefly owing to the peculiar propensity of his genius towards metaphysical fiction.

SECTION III.

ON THE ETHICS OF ARISTOTLE AND THE PERIPATETICS.

180. ARISTOTLE was a disciple of Plato, a fact which will sufficiently account for the resemblance

between their moral systems; but he was much more of a theorist than his illustrious preceptor, and this may serve to explain their principal points of difference. The same minuteness of classification, the same love of verbal distinctions, which have been already alluded to as characterising the dialectic and metaphysical writings of Aristotle, distinguish no less his ethical treatises, ten of which, addressed to his son Nichomachus, are still extant.

The whole moral theory of Aristotle was founded on his metaphysical speculations, relative to the nature and faculties of the human soul. As he taught that the soul of man is partly rational and partly irrational — the former denoting its intellectual and judicial, and the latter its sentient and active powers; so it was maintained in the Peripatetic schools, that there are two classes of virtues, corresponding with this arrangement of the intellectual powers. To the rational part of the soul belong the virtues of *integrity*, *prudence*, *wisdom*, with many others of a similar kind; to the irrational or sensitive, belong *temperance*, *fortitude*, and the like. From this classification of virtue or moral good, arose another distinction—*theoretic* and *practical:* the former manifesting itself chiefly in deliberation, and the latter in action. Theoretic virtue includes in it the right use and exercise of the powers of the understanding; practical, the pursuit of that which is right and good. Theoretic virtue is to be acquired by meditation; practical, by habit and exercise. The former of these was placed much higher in the scale of virtues than the latter, inasmuch as reason is superior to passion, and because the understanding is to be accounted the noblest faculty of man.

181. A further distinction was made by the Peripatetics, respecting those in which the body is principally concerned, and those which are external or distinct from both. For example, that species of good which in the body is termed *health*, in the soul is *temperance*, and in externals, *riches:* or what in the body is *strength*, in the soul is *magnanimity;* and in externals, *power:* or what in the body is *beauty*, is in the soul *rectitude*, or justice; and in externals, *friendship*. Among the desirable qualities of the mind are enumerated—genius, art, wit, wisdom, science, prudence; among those of the body, health, vigour, beauty, strength, and organic soundness; and among the external advantages are riches, fame, power, friends, kindred, and country. Some kinds of good are desirable on their own account, others because of their influence and tendency; some should be sought for our own sakes, and some for the advantage of others; some are to be contemplated as means, others as ends; some are honourable—as God, or parents, and princes, — others laudable, as liberty and empire; others profitable, as health, science, memory, &c. &c.

182. The *Passions* were subdivided into three classes — the *good*, the *evil*, and the *mean*, or those which occupy a middle place, being in themselves considered neither virtuous nor vicious. Of the first, were enumerated, friendship, benevolence, in-

dignation, shame, confidence, compassion; of the second, envy, malevolence, and contumely; of the last, grief, fear, anger, joy, and desire. Each of these was ramified into almost innumerable subordinate branches, which evince more the ingenuity of their inventor, than answer any valuable purpose. The principal, and perhaps the most important, feature of the moral system of Aristotle, was that which represented all virtue as consisting in the careful avoidance of every extreme, whether of excess or defect; and in steadily pursuing the middle track. Thus, fortitude is the virtuous medium between hardihood and timidity; meekness, between wrath and insensibility; liberality, between prodigality and penuriousness; magnificence, between ostentation and meanness; modesty, between impudence and bashfulness; urbanity, between rusticity and haughtiness; truth, between detraction and boasting; and friendship, between dotage and enmity. By these and many similar examples, Aristotle inculcated on his son what seems to have been with him a fundamental principle in morals, that all virtue consisted in the moderate use, and all vice, in either an excess or defect of the same quality.

183. With respect to *happiness*, it was taught in the Peripatetic school, that it was not to be sought for its own sake; that it is the certain and neccessary result of a conduct conformable to virtue; and that though the felicity which arises from the enjoyment of wealth or honours is not to be despised, *that* is incomparably superior, and

may be properly designated *perfect* and *divine*, which springs from the performance of virtuous actions.

SECTION IV.

ON THE ETHICS OF ZENO AND THE STOICS.

184. NONE of the ancient sects of philosophers boasted more of the excellence of their moral system, or made higher pretensions to exalted and disinterested virtue, than the Stoics; and it must be acknowledged that some of the best maxims and rules of moral conduct known to the Pagan world, are contained in the practical works of the most celebrated philosophers of this sect. The principle on which the entire ethical system of the Stoics was founded, and which pervades all its parts, is, that " the great end of existence, and the only rule of virtue is, *to live according to nature*," that is, in conformity with that irreversible law of fate by which all beings, divine and human, are controlled and governed. For since man, as was before stated, is a part of the Deity, and an image of the world, it becomes him to live as a part of the great whole, and accommodate all his pursuits to the general arrangement of nature. This principle is stated differently by different philosophers of this sect, but it perpetually recurs in one or other form, in all their ethical writings. Thus Chrysippus taught, that " men ought to live according to the experience

of natural events;"—Cleanthes, that "they should follow the nature common to all men;"—Diogenes of Babylon, that "they should conform to the reason and law of life;"—Panœtius, that "they should yield to the impressions of nature;"—and Posidonius yet more distinctly, that "they should contemplate truth, follow nature, and imitate God, by making the eternal reason and immutable law of the universe the rule of their actions." Thus, to live according to nature, (in the Stoical acceptation of that phrase, which was widely different from its meaning in popular language,) is the essence of virtue and of true happiness. This general principle being premised, all the other parts of the moral system taught by Zeno and his followers, obviously arise out of it. Appetites are innate principles according to nature. Passions are either morally good or evil, as they act in conformity with, or in opposition to, the great law of nature. Wisdom and virtue are those dictates of the understanding, and those actions resulting from them, which are in accordance with nature; and evil, in all its various modifications, is that which is contrary to nature. Happiness is the end assuredly to be obtained by living according to nature.

185. If from this general classification of the principal divisions of moral science, we proceed to a more particular detail, it will be found that this rule was intended to be of universal application. The two predominant appetites of all beings, are, to preserve themselves, (this being a law of their nature,) and to obtain those things which are

according to their nature, and therefore calculated to impart happiness. Those affections and passions are virtuous and good, which urge us onward to the pursuit and acquisition of that which nature approves, or which deter us from an opposite course of conduct, such as constancy, joy, contentment, delectation, cheerfulness, equanimity, &c. On the contrary, those passions are vicious which are "preternatural motions of the soul," "inward commotions, averse from right reason and contrary to nature," such as excessive desire or fear, both of which are incompatible with philosophy and virtue. The four primary passions of this class are, grief, pleasure, fear, and desire, under each of which many others are enumerated, the indulgence of which was represented as indicative of weakness and vice. Hence arose one of the chief peculiarities of the Stoical system of morals, namely, that which numbered pleasure and pain among things indifferent, which ought in no degree to affect the happiness of a wise man. Since pain, in its ordinary acceptation, is an affection of the body, and not of the mind—and since it is proved by experience not to be contrary to the law of our nature—it is not to be accounted an evil; it may, in some cases, be deemed a good; and a true philosopher may be as happy in the midst of bodily torture, as on beds of down.

186. The virtues were divided by the Stoics, as well as the Peripatetics, into two classes, the contemplative and the practical, some of which are primary, and others subordinate. The primary are, prudence, temperance, fortitude, and justice, each of

which has many others proceeding from it, as streams from a fountain. The contemplative virtues relate to truth; the practical, to the conduct of life. But the most remarkable and pernicious part of their moral system, was that which asserted the equality of all virtues and vices. As there is no medium between a straight line and a curve, so it was maintained, that every virtuous action, being in exact conformity with the law of nature, must be alike good; and every vicious act, being a deviation from nature, must be alike evil. This tenet of the Stoics formed a most vulnerable part of their system, and furnished a frequent theme of ridicule to the satirical poets.

Under the head of *Offices,* or relative duties, many useful and many trifling distinctions were introduced. The general classification of moral duties was both just and natural, being all included in those which respect God, mankind, and ourselves; but in the minute detail of these relative duties, the miserable deficiency of Pagan morality abundantly appears, since they originated in pride and selfishness, and led, in their practical results, to duplicity, dissimulation, and impiety.

SECTION V.

ON THE ETHICS OF THE EPICUREAN SECT.

187. THE next of the Grecian sects, whose moral system claims particular attention, both on account

of its celebrity, and its influence on the state of society during a long series of ages, is that of *Epicurus.* It has been generally represented as the most exceptionable, both in principle and practice, of all the ethical systems of antiquity. How far this statement is justified by facts, will appear from the following summary of its distinguishing tenets.

Epicurus taught that happiness is the great end of life, that which should be constantly pursued for its own sake, and to which every other consideration should be subordinate; that the reason why men fail in their pursuit of this object is, that they mistake its nature, and the source from which alone it can be derived:—that the highest degree of happiness to which man can attain, is that state, in which the greatest measure of physical good, and the least of physical evil, is experienced:—that pleasure being in its own nature a good, and pain an evil, the one is to be pursued to the utmost, and the other avoided; not, however, as it relates to single actions or individual character, but with reference to the whole course of human existence and the general mass of society:—that the use of the rational faculties of our nature chiefly consists in forming this estimate correctly, so as to make a wise choice, by preferring that which, *on the whole,* will yield the highest enjoyment, or by which we may avoid a greater degree of pain and suffering. The Epicurean doctrine concerning happiness, thus interpreted, may perhaps be considered (in theory at least) as not more objectionable than any other of the heathen ethical systems; but in practice it became highly injurious, subversive alike of social and private virtue, an incentive to every crime, and a pander to every species of profligacy and licentiousness.

188. The Epicurean philosophers further maintained, that pleasure is of two kinds, which are essentially distinct in their nature, and the sources from which they proceed. The one consists in *rest*, both bodily and mental, in a state of perfect and uninterrupted quiescence; the other in *excitement* and emotion, in vivid sensations and highly impassioned feelings of the mind. The former of these was considered most desirable and excellent, because according best with the intellectual part of our nature, which far excels the sensitive animal. No good attainable by man is, therefore, to be accounted greater than bodily ease combined with mental tranquillity. Arguing on these premises, Epicurus taught, that the practice of virtue is essential to true enjoyment, because that alone can induce serenity of mind and intellectual repose; that a steady course of virtuous conduct will, on the whole, secure the greatest possible degree of felicity; that, as the neglect of temperance, continence, and similar virtues, leads to pain and disease of body, so to disregard prudence, fortitude, justice, and the like, is to ensure mental anxiety and suffering. On the same ground, moderation was recommended in the pursuit of riches and honour; the regulation and subjection of the turbulent passions were enjoined; the exercise of the social virtues of compassion, benevolence, sympathy, and gratitude, was incul-

cated, as yielding the most pleasurable emotions, without disturbing the tranquillity of the soul.

189. The basis of the system being thus laid in inculcating the pursuit of happiness as the great end of life, and the practice of virtue as the surest means of obtaining it, the philosophers of this sect proceeded to a classification of the private and social virtues. In common with many other sects, they considered Prudence, Temperance, Fortitude, and Justice, as the four cardinal virtues.

Prudence, which consists in the regulation of human conduct, so as to secure the greatest possible amount of enjoyment, was subdivided into private, domestic, and civil; or that which relates to ourselves, to our families, and to the commonwealth. *Temperance,* which consists in self-government, was also variously modified; so as to include sobriety, in opposition to gluttony and drunkenness; continence, as opposed to sensuality and impure desires; meekness, as opposed to the sallies of anger and unbridled passion; modesty and humility, as opposed to ambition; and moderation, or contentment with mediocrity, as opposed to avarice in all its forms and degrees. *Fortitude,* which consists in the determined pursuit of whatever is honourable and of good report, was contemplated as connected with piety or the fear of the gods; and as counteracting and controlling the fear of death, of bodily suffering, and of mental anxiety or discontent. *Justice* was considered as a social virtue, prompting to whatever is right and just between man and man. Under this head were included humanity, beneficence, gratitude, piety, and friendship. All of these were enjoined as essential to that tranquillity of mind, which constitutes the highest enjoyment of which our nature is capable. No reference, however, was made by the founder or the followers of this infidel sect to a future state, since present felicity was the only good of which they seemed to have formed any conception.

190. If the preceding summary of the ethical doctrines of the ancient Epicureans be correct (and it is gathered from their own writings), it will be perceived, that it was not in itself that licentious system which many have imagined, or which it was represented to be by the advocates of other rival systems. It rests, indeed, wholly on the selfish principle; it urges no motives but those which are drawn from the desire of self gratification: but, as Dr. Enfield has justly observed, "it differs from the rigid system of the Stoics more in words than in reality; both maintained that virtue is happiness, though the one considered it but as a means, and the other as the end; the one represented happiness as the necessary *result* and infallible reward of virtue, while the other exhibited it as the grand *motive* to its habitual exercise." But whatever may have been the moral system of Epicurus, it is certain that the latter philosophers of his sect justified every species of crime, which promised present enjoyment; and that the system degenerated, in the more luxurious and corrupt periods of Grecian and Roman history, into habits of the grossest sensuality and voluptuousness.

SECTION VI.

ON THE ETHICAL SYSTEM OF THE ECLECTICS.

191. A BRIEF account has been given, in a former section, of the rise of the Eclectic sect at Alexandria, about the commencement of the third century, and an outline presented of the metaphysical speculations of the principal philosophers of that school. Before we close our review of the moral systems of antiquity, it is requisite to advert to that of the *Eclectics*. Here, however, it will be necessary to distinguish between the moral doctrines of those Alexandrian philosophers, who had embraced Christianity, and were of course familiar with the Jewish and Christian Scriptures, (of which number were Origen, Clemens Alexandrinus, and several others of the Greek fathers,) and those who still adhered to paganism, and were, in some instances, the bitterest and most determined enemies of the christian faith. The ethical doctrines, found in the writings of the first of these classes, may be considered as a somewhat adulterated species of christian morality. They were the precepts of revelation corrupted and debased by being amalgated with the Ammonian philosophy; on the other hand, those of the second class were the ethics of Plato, Pythagoras, Zoroaster, or Confucius, elevated, and in some degree purified, by having been brought into contact with the christian revelation. For, however inveterate may have been the enmity of Celsus, Porphyry, and other infidels of ancient or modern

times, against the gospel, it will be found that they derived their best moral maxims and rules of virtuous conduct from those very Scriptures, which they affected to despise as cunningly devised fables.

192. The following sketch of the ethical opinions of the Eclectic philosophers has been collected by Dr. Enfield, chiefly from the writings of Porphyry, and may suffice, though brief, for our present purpose.

"The mind of man, originally a portion of the divine nature, having fallen into a state of darkness and defilement by its union with the body, is to be gradually emancipated from the chain of matter, and, by contemplating real existences, to rise to the knowledge and vision of God. The great end of philosophy is, therefore, the liberation of the soul from its corporeal imprisonment. This can only be effected by the practice of virtue. For this purpose it must pass through the several stages of the human and divine virtues. Human virtues are either physical, œconomical, or political; that is, they either relate to the body, or to the offices of domestic and social life. The divine virtues are of three kinds, purgative, theoretic, and theurgic; the first consists in bodily abstinence and voluntary mortifications; the second includes all those exercises of the intellect and imagination, by which the mind contemplates abstract truth and intelligible natures; the third includes those religious exercises by which the philosopher is qualified for, and admitted to, an immediate intercourse with the superior beings, attains a power over dæmons, and rises so far above the ordinary condition of humanity, as to enjoy the vision of God in this life, and to return at death to the divine mind whence it first proceeded."

193. Nor was this moral system merely speculative. The principal founders of the Eclectic sect inculcated on their disciples the practical observance of their didactic rules. They required of them to submit to many acts of self-denial and bodily mortification, as evidences of their supposed piety and elevated virtue. The mass of the people might follow the dictates of nature, or become the slaves of their animal appetites; but philosophers were expected to be more sublimated in their dispositions and habits. They were, by the aid of meditation, to rise above all terrestrial things, and commune with the world of spirits. They were, by frequent fastings and voluntary privations and sufferings, to subjugate the body, in order that the emancipated spirit might, even in the present state of existence, be so purified and refined, as to hold communion with the Deity, to converse with invisible existences, and, by their aid, to perform many wonderful works. This was the substance of that mystical theory which was communicated to the initiated, under the name of the *theurgic art;* which was evidently derived from oriental systems of philosophy, and which, combined with the profession of christianity, produced, in subsequent ages, myriads of monks and ascetics, and led to all the rigorous austerities of popish devotees.

PART III.

THE HISTORY OF PHILOSOPHY & SCIENCE DURING THE MIDDLE AGES.

CHAPTER I.

INTRODUCTORY.

SECT. I.

CAUSES OF THE DECAY OF LITERATURE.

194. THE portion of time usually designated "the middle ages," includes a space of not less than a thousand years, extending from the dismemberment and subversion of the gigantic empire of Rome, which took place towards the close of the fifth century, to the revival of letters, which occurred about the end of the fifteenth century, and constitutes the most memorable æra in the history of the human mind. However fraught this long interval may have been with political revolutions, by which ancient dynasties were overthrown, the face of Europe and Asia changed, and the state of society, throughout the world, materially affected; to the intellectual inquirer, whose object it is to mark the operations of mind, and the progress of knowledge, it presents little more than a barren and dreary waste. Of the first five centuries, scarcely any

thing can be recorded, in connexion with the history of literature and science, except the names of a few individuals, who maintained an unequal struggle with the ignorance and barbarism that surrounded them, leaving behind them, in their voluminous writings, the memorials of their patient and persevering, though misapplied, industry in the pursuit of knowledge. The latter half of the period to be reviewed is scarcely less barren, except that some indications may be perceived, as we advance, of the gradual approach of a brighter æra, and of the emancipation of the human mind from the trammels by which it had been long enslaved. As there is little during this protracted period of intellectual darkness on which the mind can dwell with satisfaction, we shall pass over it as rapidly as possible, gleaning, as we proceed, the few scattered facts bearing upon our present object, which the annals of Europe or Asia may present.

195. The same gradation which may be perceived in all the operations of nature, and which scientific men in modern times have designated "the law of continuity," characterizes the history of mind. The transition is not found to be instantaneous from barbarism to refinement, or from refinement to barbarism. The human mind does not pass at once from a high degree of intellectual eminence, like that to which it had attained during the best days of Grecian and Roman history, to an abject state of mental captivity, like that to which it was reduced during the *middle ages.* The process was gradual, though rapid, by which this melancholy

revolution was effected. The causes were numerous which operated to produce it; and the successive stages of deterioration may be distinctly traced from the reign of the Antonines, (when it may be considered as commencing,) to the rise of the Saracenic empire, when the work of desolation was completed. There were a few men of eminence, both as philosophers and scholars, who flourished during the third and two following centuries. Some of these were mentioned in a former section of this work; men who were characterized more by patient labour and unwearied application, than by inventive and original genius. They were usefully and laboriously employed in compilations from the works of the ancients; but they will bear no comparison in intellectual attainments with the brilliant luminaries of preceding ages. Such were—Ptolemy, the far-famed astronomer; Pappus and Proclus, who commented on the works of Euclid; Ammonius, Porphyry, Aphrodiscus, Ægeus, with many others of the Eclectic sect, who wrote commentaries on the metaphysics of Plato and Aristotle; not excepting even the Christian fathers, Origen, Tertullian, Clemens Alexandrinus, and Jerome. These were chiefly connected with the Alexandrian school, which proved the last refuge of declining literature, and where the arts and sciences continued for a time to languish and decay, until at length, like withered plants, they were plucked up and trodden under foot by the Impostor of Mecca and his descendants.

196. It falls not within the limits of the present work, to examine minutely into the causes which

produced this catastrophe; but it is requisite briefly to enumerate a few, out of many, to which it may be distinctly traced. The more immediate and apparent cause to which this melancholy change is to be attributed, was (as has been already intimated) the rise of the Saracenic empire in the East, and the consequent dispersion of the men of science, who still flourished at Alexandria. "All the cultivators of the arts and sciences," says a modern writer, when describing the history of this period, "who had assembled from every nation in Alexandria, were driven away with ignominy. Some fell beneath the sword of the Arabian conquerors; others fled into remote countries, to drag out the residue of their days in want and obscurity. The buildings which had been erected, and the instruments prepared at great expense for the purpose of making astronomical observations, were involved in one common destruction. And at length, to complete the wreck, that precious depository of knowledge, the library of the Ptolemies, which had suffered greatly by fire in the time of Julius Cæsar, was now utterly consumed. The Khalif Omar directed all its books to be burned, because, said he, if they agree with the Khoran, they are useless; if they differ from it, they are pernicious and blasphemous, and, as such, should be held in universal detestation; an argument well worthy of a fanatical robber."*

197. But there were also many more remote or collateral causes contributing to the same event,

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* Bossut's Hist. of Mathem. p. 152.

some of which preceded, and others were contemporary with that alluded to in the preceding paragraph. Such were — the disorganized state of society, and general corruption of manners, in the latter periods of Roman history — the prejudices entertained by many of the fathers of the Christian Church against heathen literature — the progress of superstition—the rise of monastic institutions—the ambition, ignorance, and vices of the clergy—the imprisonment of the works of the ancients in monastic libraries, whence they were seldom permitted to emerge, and where they were disregarded and forgotten—the exclusion of the laity, however exalted their rank and station in society, from the advantages of education, and all other means of intellectual improvement—the disuse of the Latin and Greek languages, as the medium of communication between men of letters—the despotism of a few names, such as those of Aristotle and Augustine, whose works alone were sanctioned by the ecclesiastical rulers. These, with many other cooperating circumstances of a similar kind, are more than sufficient to account for the intellectual darkness that overspread the world, at the period under review.

198. But in this tremendous struggle between civilization and barbarism, between knowledge and ignorance, the former ultimately prevailed. A partial revival of letters, or at least their preservation from total ruin, may be traced to the very people who had threatened their existence, and endeavoured to effect their destruction. After the lapse of about

a century from the rise of the Saracenic empire, a succession of Khalifs arose who patronized learning, and collected at Bagdad, the principal seat of empire, a considerable body of philosophers and mathematicians. The latter were chiefly held in estimation, on account of the intimate connexion which was perceived to exist between the abstract sciences and practical astronomy; a branch of physical knowledge to which the oriental nations had been from the earliest ages passionately devoted, not so much for its own sake, as from a belief that the knowledge of the stars would enable them to prognosticate future events.*

SECTION II.

ARRANGED LIST OF THE PHYSICAL AND INTELLECTUAL PHILOSOPHERS OF THE MIDDLE AGES.

199. IN this division of the work, instead of attempting so minute a classification as that adopted in the preceding pages, it will be sufficient to arrange the scanty materials with which we are furnished, under two general heads; the first including the *History of Physical Science* during the middle ages; and the second, that of *Intellectual and Moral Science*, for the same period. It may not, however, be unacceptable to the juvenile reader, before entering on this retrospect, to be furnished with a

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* Gibbon's Decline and Fall, Vol. V. p. 423—425.

list of the principal philosophers and men of science who flourished between the sixth and sixteenth centuries.

CLASS I.—SCIENTIFIC PHILOSOPHERS.

ASIATICS.		A.D.
Geber	—	650
Al-mansor,	Khalif of Bagdad	760
Al-haroun	*ibid*	800
Al-maimon	*ibid*	830
Albumasar	Bagdad	840
Alfragan	*ibid*	850
Thebit	*ibid*	850
Alkendi	*ibid*	860
Albategni	*ibid*	900
Alfarabi	*ibid*	950
Mohammed	(Ben Musa)	950
Ebn Younis	Egypt	960
Abul-Wefa	Bagdad	980
Avicenna	Bochara	1000
Geber	(Ben Aphla)	1040
Arsachel	Toledo	1040
Mohammed	Bagdad	1100
Averroes	Corduba	1130
Alhazen	*ibid*	1150
Albaithar	Malaga	1160
Maimonides	Corduba	1160
Alcazuini	Persia	1250
Ebn Fadhl	Egypt	*ibid.*
Ebn Aluam	Corduba	*ibid.*
Albiruni	Persia	*ibid.*
Abulfeda	Hamah, in Syria	1325
Nassar Eddin	Persia	1400
Ulugh Beg	Tartary	1430

EUROPEANS.		A. D.
Gerbert	Sylvester II.	950
Leonardo de	Pisa	1200
Albert	Ratisbon	1240
Jordanus (Nem.)	—	1250
John (Sacrobosco)	Halifax	*ibid.*
Campanus de	Novara	*ibid.*
Gerard	Cremona	*ibid.*
Frederic II.	Germany	*ibid.*
Grostèste	Bp. of Linc.	*ibid.*
Simon de	Tournay	*ibid.*
Roger Bacon	Ilchester	1260
Alphonsus II.	Kg. Castile	*ibid.*
Vitello	Poland	1270
Peter the	Dane	1285
Richard de	Swineshead	1330
Wallingford	—	1350
Ulsman Strame	Nuremberg	*ibid.*
Lucas	(de Burgo)	1400
Nicholas	(de Cusa)	1445
Laurentius	Haarlem	1445
P. Schoeffer	Strasburg	1450
John Faustus	Mentz	1450
Purbach	Vienna	1450
Regiomontanus	Rome	1470
Walther	Nuremberg	1480
Werner	*ibid*	*ibid.*
Benedetto	Italy	*ibid.*
Bianchini	*ibid*	*ibid.*
Angelo	Florence	*ibid.*
Ferdinand	Cordova	*ibid.*
Bernard	Granolachi	*ibid.*

CLASS II.

DIALECTICIANS AND SCHOLASTICS.

I. *Between* A. D. 500 *and* A. D. 1000.

		Flourished.
Cassiodorus	—	510
Boethius	Athens	*ibid.*
Simplicius	—	550
Gildas	—	*ibid.*
John of	Alexandria	620
Isidore	Seville	*ibid.*
Bede	Jarrow	720
Joannes	(Damascenus)	770
Alcuin	York	770
R. Maurus	Mentz	830
Photius	Constantinople	850
Psellus, Sen.	*ibid*	850
Joannes Scotus, *surn.* Erigona		860
Leo	Constantinople	880
Eustrathius	*ibid*	*ibid.*
Nicephorus	*ibid*	*ibid.*
Magentinus	Mitylene	*ibid.*
Hincmar	Rheims	*ibid.*
Grimbald	—	890
Winfrid	—	900
Bridfurth	—	920
Dunstan	Abp. Cant.	940
Remigius	Auxerre	*ibid.*
Constantine	Paris	*ibid.*
Abbo	St. Germain	*ibid.*
Nanno	Friesland	*ibid.*
Baldric	Vienna	*ibid.*
Gerbert	(P. Sylvest. II.)	950
Herman	Mentz	980

II. *Between* A. D. 1000 *and* A. D. 1500.

SCHOLASTICS OF THE FIRST PERIOD.

		Flourished.
Lanfranc	Abp. of Cant.	1055
Berenger	Cologne	1080
Fulbert	Paris	*ibid.*
Bruno	Cologne	*ibid.*
Anselm	Abp. of Cant.	1100
Roscelline	Brittany	*ibid.*
Champeaux	Paris	*ibid.*
Abelard	*ibid.*	1120
P. Lombard	*ibid.*	1150
Porretan	Poictiers	*ibid.*
John of	Salisbury	1160
Hales	Glocester	1200
THE SECOND PERIOD.		
Albert (Mag.)	Cologne	1250
Bonaventure	Tuscany	*ibid.*
Thomas Aquinas	Cologne	*ibid.*
Grostèste	Bp. of Lincoln	*ibid.*
Roger Bacon	Ilchester	1260
Columna	Paris	*ibid.*
Robert de Sorbonne,	Paris	*ibid.*
Duns Scotus	Oxford, &c.	1290
Mayro	Paris	*ibid.*
Arnaud de	Ville Neuf.	*ibid.*
THE THIRD PERIOD.		
Occam	Oxford	1320
Durand	Clermont	*ibid.*
Burley	—	*ibid.*
Raymond Lully	Majorca	*ibid.*
Wickliffe	Lutterworth	1360
Petrarch	Tuscany	*ibid.*
Argyropulus,	Constantinople	1440
Chrysoloras	*ibid.*	*ibid.*
Wessel	Groningen	1450
Laur. de Valla	Rome	*ibid.*
Politian de	Tuscany	*ibid.*
Pletho	Constantinople	1480
Lascaris	Florence	*ibid.*

CHAPTER II.

THE HISTORY OF PHYSICAL SCIENCE DURING THE MIDDLE AGES.

SECTION I.

ON THE REVIVAL OF MATHEMATICAL KNOWLEDGE AMONG THE ARABIANS.

200. Little more than a century had elapsed from the establishment of the Saracenic empire by the military prowess of Mohammed, before those very arts and sciences began to be successfully cultivated at Bagdad, under the patronage of the Khalifs, which had been proscribed and ignominiously banished from Alexandria by the barbarous founders of that empire. Many valuable remains of antiquity had fallen into the hands of the conquerors, which, though at first little regarded, and even held in the utmost contempt, began by degrees to be studied, admired, and translated into their vernacular tongue. Among these were the works of the most celebrated Greek mathematicians, the study of which had the effect of exciting a taste for the abstract sciences, hitherto unknown in that part of the world.

201. To some of the Arabian mathematicians of the middle ages, Europe is indebted for most valuable improvements in arithmetic. The invention of this useful and important science has been traced to very remote antiquity, though it cannot with certainty be determined in what æra, or among what people, it originated. Several distinct periods can also be pointed out in which the art of numerical calculation underwent material improvements. Among these may be particularly noticed the æra of *Nicomachus,* who was a contemporary of Euclid, and wrote a highly scientific treatise on the theory of numbers; and that of *Claudius Ptolemæus,* who flourished about A.D. 200, and is said to have invented the *sexagesimal arithmetic,* or the method of calculating both integral and fractional quantities by *sixties.* But the most valuable improvement in arithmetical science was introduced, if not invented, by the mathematicians of Arabia about the eighth century. The contrivance to which we refer is, the *method of decimal notation,* or that by which each figure in the decimal scale is made to change its signification and power, as its position is changed, being increased in value tenfold for every place that it advances towards the left hand. There is no reason to believe that this method of notation was known either to the oriental arithmeticians, or to those of Greece and Rome; but several Arabic MSS. of the eighth and ninth centuries, still extant, prove it to have been a mode of calculation then generally adopted. Gerbert, a monk of the Low Countries, (who was afterwards raised to the pontifical chair, and assumed the title of Sylvester II.), resided for a considerable time among the Saracens in Spain, for the purpose of becoming acquainted with this new system of arithmetic, and by him the knowledge of the art was communicated, about A.D. 960, to the mathematicians of Europe.

202. It has been much disputed whether *Algebra* was invented, or only improved, by the Arabians. Some highly respectable authorities (among whom were Cardan and Wallis) incline to the former opinion; while others, whose authority is at least equal to theirs, have contended for the latter. Professor Playfair, in his elaborate Dissertation on the Origin and Progress of Mathematical Science, prefixed to the supplementary numbers of a late edition of the Encyclopædia Britannica, asserts, that "the knowledge of algebra was unquestionably transmitted to Europe by the Arabs; but its invention must be sought for much farther to the East, probably not nearer than Hindostan." This is even admitted by the Arabic writers themselves; for it is stated in some of their MSS. works on this science, that Mohammed Ben Musa (to whom we shall have occasion again to advert as the most eminent of the Arabian mathematicians) travelled into India, about A.D. 959, for the purpose of receiving further instruction in algebraic science. The difference between the algebra of Diophantus, who published a treatise on this subject, in the Greek language, about A.D. 800, and that of the Arabs, both with respect to the terms employed, and their method of notation, is so great, as to prove that the knowledge they respectively possessed of this science must have been derived from different sources; and that either the algebra of the latter was self-invented, or derived

from a source with which Diophantus was wholly unacquainted. It is not easy, from the want of sufficient materials on which a judgment may be founded, to determine what progress was actually made by the Arabian arithmeticians in algebra. M. Bossut affirms, that "there are indications in some existing Arabic MSS. that they advanced as far as to the solution of equations of the third and even fourth order, in which they advanced beyond Diophantus, who did not resolve any beyond the second." The Leyden Library, he adds, contains an Arabic MSS. entitled, "The Algebra of Cubic Equations."

203. The most important service rendered by the Arabian mathematicians to geometrical science, consists in their preservation of many works of the ancients, which, but for them, had inevitably been lost to posterity. Some of these are still only known to Europeans through the medium of Arabic versions; but with respect to others, the originals, which were long supposed to have perished, have been brought to light by the researches of scientific men in later ages. The "Elements" of Euclid, the treatises of Archimedes "on the Sphere and Cylinder," the "Spherics" of Theodosius, the treatise of Menelaus on "Spherical Triangles," and the "Conic Sections" of Apollonius Pergœus, were all perpetuated and handed down to posterity by their means; and with respect to the last of the above-mentioned works, the fifth, sixth, and seventh books have never appeared in their original form, but were printed in an Arabic version at Florence, A.D. 1661.

204. Next to the preservation of the labours of ancient geometricians, may be mentioned the progress made by the Arabians themselves in trigonometrical science. This was, perhaps, the most defective part of the geometry of the ancients; but the Arabian mathematicians of the middle ages first applied to this department of science the simple and commodious method of calculation which is now generally adopted. They reduced the resolution both of plain and spherical triangles to a small number of simple propositions; and by introducing the practice of measuring them by *sines,* instead of *double arcs,* rendered calculations, in themselves extremely complicated and difficult, perfectly simple and easy. These important improvements in geometrical science are chiefly attributed to ALBATEGNI, or *Geber,* the son of Mahomet, an Arabian prince, (who flourished about A. D. 880,) who, though most celebrated as an astronomer, greatly promoted the science of trigonometry, by the introduction of *sines, versed sines, tangents,* and *secants*;—to MOHAMMED (BEN MUSA), who flourished about the middle of the tenth century, and wrote a work, still extant, on "The Measurement of Plain and Spherical Figures;"—to GEBER (Ben Aphla), a mathematician and astronomer of the eleventh century, who is best known by his laborious and scientific commentary on the works of Ptolemy;—and, more than all, to EBN JOUNIS, who flourished under the Khalif Hakem, (about 1050,) who most successfully applied the sexagesimal arithmetic, then in use, to complicated trigonometrical calculations and measure-

ments.* To these may be added, an elaborate and elegant work on "Practical Geometry," written, at a somewhat later period, by Mohammed of Bagdad; a treatise, which some modern writers, who are unwilling to attribute any inventive powers to the Arabians, have ascribed, though without any adequate reason, to Euclid.

SECTION II.

ON THE ARABIAN ASTRONOMERS OF THE MIDDLE AGES.

205. FROM the time of Ptolemy, who may be considered as the last of the ancient astronomers, this sublime science, so far from having advanced in any part of Europe or Asia, evidently retrograded and almost disappeared, till nearly the close of the eighth century, when a partial revival of literature and science in general, but especially of astronomy, took place under the auspices of several of the Saracenic Khalifs, who were both distinguished patrons of learning, and scientific philosophers of no mean reputation. (1.) The first of these was Abou Giafar, surnamed AL-MANSOR, or the Victorious, who reigned about A. D. 760. The period during which this Saracenic Chief presided over the Arabian empire, forms the epoch in which an impulse was given to science, the effects of which were apparent many centuries after his death. The

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* Vide Leslie's Elements of Geometry, pp. 373, 374.

principal object which engaged the attention of the Khalif, and to which all the time which he could spare from public business was devoted, was, the regulation of the calendar by an accurate observation of the motions and revolutions of the sun and moon. Aided by the astronomers whom he gathered around him from all parts of the world, he determined the degree of the obliquity of the ecliptic to be nearly the same as the more accurate observations of modern science have proved it to be; a discovery which is the more remarkable, on account of the imperfection of the astronomical instruments then in use, the telescope not having been as yet invented. (2.) AL-HAROUN, the grandson and successor of Al-Mansor, who reigned from A. D. 786 to 809, and his son, AL-MAIMON, who held the caliphate from A. D. 813 to 833, carried on with much zeal and assiduity the literary projects of their ancestor. They became eminent astronomers, as well as liberal patrons of the arts. The former of these princes, though chiefly celebrated as a most ingenious mechanician, (and who will therefore be more properly noticed hereafter,) was no mean proficient in the science of astronomy; but the latter was its most munificent patron and zealous promoter. He seems to have been early imbued with the love of science, by the example and instructions of his preceptor and physician, who professed the Christian religion;* and from the time of his accession to the hour of his death, continued to exert his utmost influence for the advancement of the arts and sciences. He caused all the Greek MSS. on scientific objects, which he could procure, to be translated; particularly Ptolemy's *Almagest*, alluded to in a former section, as containing a valuable digest of ancient astronomy. He appropriated much of that wealth, which his predecessors had accumulated, to the purchase of ancient MSS., to the erection of magnificent observatories, and to the construction of costly instruments for mathematical and astronomical purposes. Many observations were made by himself in his hours of leisure; but a far greater number by the men of science whom he summoned to his court from distant provinces. Among the important astronomical undertakings of this reign, the principal were—to verify the observations made by the preceding Khalif, relative to the obliquity of the ecliptic—to measure a degree of the earth, both on the plains of Sinaar and those of Cusa (by which it was determined that the entire circumference of the globe amounted to 24,000 miles)—and to compile from all the astronomical works of antiquity

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* Of the literary character of this preceptor of Al-Maimon, the following account is given by Berrington, in his History of the Middle Ages:—"When the son of Mesuach, a young Nestorian Christian, retiring from his own country, first entered Bagdad, he

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appeared to have discovered a new world. He saw that the followers of Christ and of Mahomet were there engaged in the pursuit of the liberal arts. Here then he remained, applying himself to medicine, philosophy, and astronomy. His acquirements became great, and his knowledge of languages extensive; whence, himself being a treasure of learning, he was chosen to attend on Prince Al-Maimon, the son of the Caliph Al-Raschid, and to accompany him on an important embassy."—P. 647.

a complete digest of the science, in a work still existing, though of great rarity, entitled "Astronomia elaborata a compluribus DD., Jussu regis Maimon."

206. Our first attention having been paid to the royal astronomers of this age, it is requisite next to advert to those of inferior station, but probably of far superior science, who flourished under their auspices, or about the same period. The most distinguished of these, (as far as a judgment can now be formed respecting them, either by their writings or the brief notices of ancient historians,) were Alfragan, Thebit, Albategni, and Alkendi.

(1.) ALFRAGAN, who flourished A. D. 850, is best known as the author of a work, entitled "Elements of Astronomy," which was considered at the time, and long continued to be esteemed, a standard work in that department of science. He wrote also treatises on "Solar Clocks and the Astrolabe," which still exist in MS. On account of the facility with which he made the most difficult and complicated arithmetical and algebraic calculations, he was designated by his contemporaries, the *Calculator*.

(2.) THEBIT was nearly contemporary with the last-mentioned astronomer. Though none of his writings have been discovered, it may be gathered, from the testimony of others, that he rendered important services to astronomical science "by his attentive observations on the sun's motion, with relation to the fixed stars; thus determining, with a precision which is most remarkable, the length of the solar and sidereal years." He was, however, misled by the Ptolemaic system, the only one then known; and in order to reconcile his observation of facts with that system, was compelled to invent theories both unphilosophical and contrary to truth.

(3.) ALBATEGNI, the third and by far the most distinguished of the above-mentioned astronomers, flourished towards the beginning of the tenth century. He was designated (and not without reason) *the Arabian Ptolemy*, though he might with greater justice have been honoured with the name of Hipparchus, since he not only resembled the astronomer of Alexandria in the number and extent of his observations, but, possessing a genius like that of Hipparchus, seems almost to have anticipated the discoveries of future ages. The most important of the astronomical researches of Albategni related to the precession of the equinoxes, which he determined to amount to one degree in seventy years—to the eccentricity of the solar orbit, which he found to be precisely such as modern astronomers have fully demonstrated it to be—to the calculation of the length of the year, which differs but two minutes from the true time—to the variations in the sun's apogee, which, till then, had never been observed—and to the irregularities of the planetary motions, which, though only conjectured by him, modern science has proved, and satisfactorily explained. The works of Albategni have been long since published, in one quarto volume, under the title of "Scientia Stellarum."

(4.) ALKENDI, who flourished somewhat earlier than Albategni, though far inferior in science, is eulogized in the most extravagant terms by the historians of this period. He was styled "the root of the age, the phœnix in the circle of the sciences, and the great Arabian philosopher;" and if his scientific attainments could be fairly estimated by the number of subjects on which he wrote, he must have merited in some degree these high commendations; for, from his pen, proceeded works on geometry, arithmetic, algebra, astronomy, logic, pneumatology, medicine, music, with many others too numerous to mention.

207. Besides those already adverted to, many other mathematicians and astronomers have been enumerated by the historians of this period, of less distinguished reputation. Among these may be mentioned some natives of Arabia, who settled in Spain, and being powerfully patronized by the princes of the house of Omar, (commonly designated the *Ommiades,*) founded schools of astronomy in the chief cities, erected observatories at great expense, and undertook scientific works of immense labour. Such were—*Arsachel,* a Spanish Moor, who observed the obliquity of the eclipses, applied the principles of trigonometry to the measurement of the distances of the heavenly bodies, and prepared and arranged, with prodigious industry, a series of astronomical tables, entitled "Tabulæ Toledanæ," from the city of Toledo, in which the observations were made—*Geber* of Grenada, chiefly known as a translator and commentator of the "*Almagest*"—*Almansor, Averroes* of Corduba, with many others.

208. But passing over these, it is requisite to notice more distinctly three astronomers who flourished at different periods and in distant countries, though they were ardently devoted to the same scientific pursuits. These were respectively natives of Egypt, Persia, and Tartary, and were the principal astronomers of the several ages in which they lived.

(1.) During the caliphate of Azir Ben Hakem, that is, about the end of the twelfth century, IBN IONIS, or *Ebn Younis,* distinguished himself by his knowledge of astronomy, in a country which may almost be considered the birth-place of that noble science. The details of his scientific observations are contained in his "Survey of the Heavens;" a work which still exists in MS. in the Leyden Library, and contains an accurate description of twenty-eight eclipses that occurred between A. D. 829 and 1004—seven observations of equinoxes between 830 and 851—and one of the summer solstice in 832. Three of the eclipses, which happened in 977, 978, and 979, afforded him an opportunity of observing and accurately measuring the quantity of the moon's acceleration—an observation for which subsequent astronomers owe him great obligations.

(2.) NASSIR EDDIN flourished about A. D. 1264, during the administration of Houlager Khan, one of the descendants of the celebrated warrior, Genghis Khan. The astronomical observations of Nassir Eddin were chiefly made at Tauris in Media, where an observatory had been erected by the liberality of the Khan, and a considerable body of astronomers were assembled, over whom Nassir presided. He composed several works on astronomy, among which were "a Theory of the Motions of the

Heavenly Bodies, a Treatise on the Astrolabe, and a large collection of Astronomical Tables."

(3.) **Ulugh Beg**, grandson of Tamerlane, the Tartar Chief, greatly excelled in practical astronomy, at a period in which literature and science seemed almost extinct—about A. D. 1437. He is celebrated partly on account of the magnitude of the astronomical instruments with which his observations were made—the quadrant or gnomon, employed by him, being said to equal in height the church of St. Sophia, in Constantinople, *i. e.* about 180 feet—partly because of the astronomical tables which he composed from his own observations for the meridian of Samarcand, the capital of his empire, and which were so exact as to differ but in a slight degree from those of Tycho Brahe, the Danish astronomer; but chiefly on account of his catalogue of the fixed stars, made A. D. 1437, which was far more complete than that of any preceding astronomer. Several of the works of Ulugh Beg have been printed, and MS. copies of the rest are preserved in the libraries of the curious. This munificent patron of science, and distinguished scholar, was assassinated by his own son in the fifty-eighth year of his age, and with him the literature of Persia expired.

SECTION III.

ON THE PROGRESS OF EXPERIMENTAL PHILOSOPHY AMONG THE ARABIANS.

209. IN the two preceding sections, a sketch has been presented of the literature of Arabia during the middle ages; from which it will appear, that both the mathematical sciences and astronomy were cultivated successfully in that part of the world, when they had almost ceased to exist in every other. These, however, were not the only departments of physical science, to which attention was given by the philosophers of Arabia, during the period under review. Though the far greater number of the literati of those dark ages were geometricians, algebraists, and astronomers, proofs are not wanting, that some among them made a considerable proficiency in *mechanical* and *optical* science; and it is well known that to this æra of intellectual darkness, and to the Arabians especially, must be traced the origin of the science of *chemistry*, than which perhaps none, in the whole circle of the sciences, has been productive of more valuable results. Few are the individuals, it is true, whose names have been preserved in connexion with these several departments of practical philosophy, and still fewer the proofs which remain of their unwearied industry and patient researches; but the more rare their occurrence, and the more scanty our information concerning them, the more desirable it is, that the

few scattered facts which can be collected from the records of past ages, respecting these individuals and their works, should be preserved.

210. In vain shall we look for an Archimedes among either the European or the Asiatic philosophers of the middle ages; but enough is known to make it evident that mechanical science was not wholly lost. In proof of this, it will be sufficient to adduce a single fact, which is related of Haroun, the grandson of Almansor, to whom we have already referred as a celebrated astronomer. That prince was a contemporary of Charlemagne, the celebrated French monarch, who was also a munificent patron of literature and the arts. Haroun, having determined to send an embassy to Charlemagne, (A.D. 799,) at the same time charged his ambassador with a present, which was then deemed little less than miraculous, and which, it must be acknowledged, has rarely been surpassed even by modern science. This was a *clepsydra,* or water-clock, of most ingenious construction. In the dial-plate were twelve doors at equal distances, on which were inscribed the hours successively; each of those doors opened in its turn, and let fall, upon a brazen bell, a sufficient number of balls to strike the proper hour of the day. They continued open till twelve o'clock, when twelve little knights, mounted on horseback, issued simultaneously from a part of the machine, paraded round the dial, and having closed the twelve doors, as suddenly retired. That the construction of such an instrument, in such an age, should have astonished all Europe, is not surprising; and it may

not unreasonably be concluded, that the mechanical science which was requisite to produce so curious an instrument of measuring time, must have produced many others of far greater utility and importance.

211. During the twelfth century, Alhazen, a celebrated Arabian astronomer, flourished and wrote; who is introduced in this place, because his scientific researches chiefly related to *optical science*. He made numerous experiments on refracted and reflected light, and on the phænomena of vision,—subjects which had either escaped the attention of the ancients, or in the investigation of which they were unsuccessful. By his accurate observation of facts, he succeeded in discovering some phænomena before unknown, and in explaining others previously deemed inexplicable. On the principle of refraction, he accounted for the enlarged appearance of bodies immersed in water, or seen through crystalline substances—the increased apparent magnitude of the heavenly bodies, when near the horizon—and all the phænomena of twilight. This refraction he supposed to depend not on the density of the vapours accumulated near the surface of the earth, but on the difference of transparency between the atmospheric air which surrounds the globe, and an imaginary ethereal matter placed beyond it. Following up this theory, he proposed rules by which to ascertain the difference between the real and apparent place of any given star. Whatever may have been the success of Alhazen in his experiments on optics, to him unquestionably belongs the honour of having directed the attention of future philosophers to a

highly interesting and important branch of physical science. His theory on this, and many similar subjects, is fully explained in several of his treatises on optics, which still exist, and are deemed great literary curiosities.

212. The first rude notions of *Chemistry*, regarded as a branch of experimental philosophy, originated among the Arabians, about the tenth century, under the name of *Alchemy*, an Arabic term, which denotes, " a knowledge of the substance or composition" of any thing. An ingenious modern writer has traced still higher the origin of this science, by attributing it to the New Platonists, or Eclectic philosophers of the third century; while some have traced it yet farther back (as already stated), to the ancient Egyptians, to Moses, and even to the antediluvians. But whatever opinion may be formed respecting the origin of the science, it is agreed by all to refer to the Arabians of the middle ages the practical exercise of the art of alchemy, (properly so called,) or the decomposition and analysis of natural substances for the purpose of ascertaining their qualities and relations. The two leading objects proposed by the alchemists were, the transmutation of common metals into gold and silver, and the discovery of an universal medicine, which, by the removal or prevention of disease, should confer immortality on its possessor. It is not difficult to account for the origin of these extravagant expectations in so dark and superstitious an age. When it was perceived that metallic ores, and many other natural substances, changed their appear-

ances, and evinced new qualities, when variously combined or exposed to the action of heat, it was natural that some chimerical notion, like that of *the philosopher's stone,* should spring up in the minds of persons peculiarly fond of the marvellous, and as yet unpractised in experimental philosophy.

213. The rage for this species of chemical researches lasted many centuries, though it was confined to comparatively few individuals. Its earliest traces may be perceived in the seventh or eighth century, and it attained its height during the sixteenth, or just before the revival of letters.

The first of the alchemists of Arabia known to posterity is *Geber,* whose personal history has not been preserved, though some of his writings remain. He is said to have flourished during the seventh century, to have been a celebrated physician and astronomer, and to have written a great variety of works on alchemy. The principal which have been attributed to him bear the following titles: "On Alchemy;" "On the chief Perfection of Metals;" "On the Philosopher's Stone;" and "On the Art of discovering Gold and Silver." During the ninth and tenth centuries, several Arabian physicians, of whom Avicenna was the most distinguished, practised and wrote on the art of alchemy. In the three following centuries, the number of professed *adepts,* as they were then termed, or skilful practitioners in chemical philosophy, was greatly multiplied — the most laborious processes were carried on with exemplary patience—and the most romantic expectations indulged of ultimate success. "But though the alchemists failed in the execution of their grand project, many useful discoveries were made by them, while vainly spending their time and labour in attempts to make silver and gold. Some important combinations were produced, by which pharmacy has been enriched, and the science of medicine promoted. The method of preparing alcohol, aqua-fortis, volatile alkali, vitriolic acid, gunpowder, and many other chemical compounds, might have remained unknown, but for the persevering labours and patient experiments of the alchemists of the middle ages."

SECTION IV.

ON THE EUROPEAN MATHEMATICIANS AND ASTRONOMERS OF THE MIDDLE AGES.

214. THE partial revival of literature and science in Arabia, has been first noticed, because it preceded, in the order of time, that which took place in Europe during the twelfth and two following centuries; and, because the impulse was first received from Arabian scholars, which subsequently extended itself over the European continent. Having taken a very cursory view of the state of mathematical and physical science in the East, after its expulsion from Greece and Egypt, we now return to that portion of the world, which has, for many ages, excelled every other in civilization and general knowledge. Passing over a period of not less than six or seven

centuries, we recommence our review of European literature with the beginning of the thirteenth century; and as, at that period, mathematical and astronomical science kept pace with each other, and were usually cultivated by the same individuals, they will be jointly considered in this place.

215. Spain and Italy were the two provinces of Europe that first caught the reflected rays of science from Arabia. In the former of these countries, the revival of knowledge is chiefly to be attributed to the residence of eminent Arabian scholars in some of its principal cities — the establishment of schools and colleges—and the collection of large and valuable libraries, consisting of MSS. on every department of science. Into the latter country (Italy) it seems to have been rather accidentally than designedly introduced. LEONARDO, an opulent merchant of Pisa, visited the Asiatic provinces for purposes of commerce. During his temporary residence at Bagdad, he associated frequently with the Arabian literati of that city, and made himself acquainted with their most important discoveries, especially those which related to arithmetic and algebra, in both which sciences he became a distinguished proficient. The knowledge thus acquired, he lost no time in imparting to his countrymen; and, by doing this, obtained the honour of introducing into Europe, a science before wholly unknown, but which has ever since occupied a chief place among the objects of human intelligence. Though he was well known to have left many valuable MSS. (chiefly on the new algebraic science,) none were supposed to have

escaped the wreck of ages, till about the close of the last century; when a learned Italian referred to a MS. written by Leonardo of Pisa, which he had discovered in a monastic library, bearing the date of A. D. 1202, and which has since been published. From this ancient document it is evident, that its author was a skilful algebraist; that he was not unacquainted with the problems of Diophantus; and that he had, at least, proceeded as far as to the resolution of cubic equations.

216. In a more advanced period of the same century, several mathematicians and astronomers flourished in different parts of Europe, whom it will be sufficient cursorily to notice. (1.) *Jordanus Nemorarius,* author of a treatise on the Astrolabe, and a work on Arithmetic, in ten books. (2.) *John of Halifax,* (better known by the name of *Sacrobosco*), an Englishman by birth, but resident at Paris, as professor of mathematics. His principal work, on "the Sphere," acquired great celebrity; besides which, he wrote treatises on the Astrolabe, the Calendar, and the Arabian Arithmetic. He flourished about A. D. 1250. (3.) *Campanus* of Novara, is best known as one of the first European Commentators on Euclid's Elements; and also as the author of several works on astronomy, which were designed to make known the discoveries of the ancient astronomers, together with the improvements which had been more recently suggested by the Arabians. (4.) To the preceding may be added, *Gerard of Cremona,* and his illustrious patron, the Emperor FREDERIC II; the latter of whom liberally

patronized the arts, by founding the university of Naples; and the former, having been appointed its first professor of astronomy, rendered an important service to science, by translating, from the Arabic into Latin, the *Almagest* of Ptolemy, with Geber's Commentary; those parts of Aristotle's writings which relate to Physics; and Alhazen's treatise on Twilight, besides composing several original works.

(5.) A name far more celebrated in the history of science than any of the above-mentioned mathematicians, must not be passed over in this place, though we shall reserve for a future section, the more distinct record of his scientific discoveries. This was Roger Bacon, an English friar, who was born A. D. 1214, and died in 1294. When the ignorance of the age in which he lived, and of the monks with whom he associated, compared with his almost universal knowledge, is considered, it must be acknowledged that he was a prodigy of genius and erudition; and that very few, either in ancient or modern times, have surpassed him, either in originality of invention, or in profundity of research.

217. The thirteenth century is chiefly memorable in the annals of astronomical science, as the æra in which the celebrated *Alphonsine Tables* were prepared by the united labours of the most distinguished astronomers of the age, both Asiatic and European, whether Christians, Saracens, or Jews. They derive their name from Alphonsus II. who reigned in Castile, A.D. 1240. Their object was to correct the errors which had been discovered in the calculations of Ptolemy, and

produce a new series, more complete and accurate than any which had preceded them. The expense incurred by this scientific undertaking is said, by some historians of that age, to have exceeded 40,000, and by others 400,000 ducats. As soon as the Alphonsine Tables were made public, they attracted the attention of the principal mathematicians and astronomers both of Europe and Asia; several of whom wrote treatises explanatory of their details, or intended to correct their supposed errors.

218. The following century (the fourteenth) was one in which true science manifestly declined throughout Europe, in consequence of the ecclesiastical domination maintained by the clergy, and the frivolous logomachics of the scholastics, to which we shall allude more particularly hereafter. Scarcely do the literary annals of that age furnish us with the name of an individual, who excelled either in mathematics or astronomy, though many were laboriously employed in writing commentaries on the works of the ancients. One exception to the above remark must be made in favour of *Richard of Swineshead*, who taught the mathematics and astronomy in the university of Oxford, about A. D. 1350. His works chiefly "consist of profound and subtle applications of algebraic calculations to physics and metaphysics." He wrote treatises "on astronomical calculations," which indicate, to say the least, the patient industry and ingenuity of their writer, and his great skill in algebraic processes. Passing over this inauspicious æra, we shall immediately advance to the fifteenth century, during which these sciences

experienced a partial revival, and some highly gifted individuals arose, whose genius illumined the age and country in which they lived.

219. The first of these, in the order of time, was *Lucas de Burgo*, an Italian monk of the Franciscan order, who, after having employed several years in the East, in assiduous studies, brought thence a mass of scientific information, which qualified him to sustain the office of professor of mathematics and astronomy in the recently founded universities of Naples, Venice, and Milan. His principal works were, "A Latin Version of Euclid's Elements," with notes; a treatise "on Algebra," in his native tongue; and "Elements of Geometry," prepared by himself; with several other tracts on philosophical subjects, to which his attention had been directed by the Arabians.

The Cardinal, *Nicholas de Cusa*, who flourished about A.D. 1445, is chiefly celebrated on account of his attempt to revive the *Pythagorean* notion of the earth's motion round the sun, in opposition to the *Ptolemaic*, which then universally prevailed. It is not a little extraordinary that an opinion so contrary to the orthodox faith in philosophy, should have been propagated with impunity in such an age; the announcement and vindication of which, nearly two centuries after, consigned Galileo to the dungeons of the Inquisition. It is probable that Nicholas owed his safety to his high ecclesiastical rank, and to the universal rejection of his theory.

220. PURBACH next occurs among the mathematicians of the fifteenth century. He was born

A. D. 1421, and died in 1461. Attracted to Vienna by the liberal patronage of Frederic II., he succeeded *Gmunden* as professor of astronomy in the university recently founded by the emperor in that city. There he acquired great celebrity by his scientific discoveries and his writings. His first object was to produce an accurate translation of Ptolemy's "*Almagest*." This had been often attempted, but every previous attempt had failed. He next directed his attention to the improved construction of celestial spheres and globes, in which the stars and constellations then known to astronomers were more accurately laid down. Thence he proceeded to form new and enlarged tables of the fixed stars, and determine their relative positions. In addition to these his principal labours, Purbach employed all his leisure time in writing numerous treatises on arithmetic, algebra, geometry, astronomy, and several other departments of natural philosophy. Nor was it the least valuable of the services rendered by this eminent astronomer, that he first introduced into trigonometry those abbreviations which are now generally adopted, by means of which calculations in that science have been greatly facilitated.

221. But the brightest luminary of this dark age was MÜLLER, better known by the name of *Regiomontanus,* which he derived from the place of his birth. To the literary eminence of this disciple and successor of Purbach, a modern writer of high authority has borne the following honourable testimony: "Regiomontanus is the mathematician

who holds the highest rank among those of the fifteenth century. To him we owe many translations and commentaries, together with several original and valuable works of his own. Trigonometry, which had never been known to the Greeks as a separate science, and which took that form in Arabia, advanced, in the hands of Regiomontanus, to a great degree of perfection, and approached very near to the condition which it has attained at the present day. He also introduced the use of decimal fractions into arithmetic, and thus gave to that scale its full extent, and to numerical computation the utmost degree of simplicity and enlargement which it seems capable of attaining."* Among the versions effected by Regiomontanus, were latin translations of "the Conics of Apollonius"—"the Cylindrics of Serenus"—"the Mechanical Questions of Aristotle"—"the Pneumatics of Hero," and "Ptolemy's Almagest," all of which versions were enriched by him with highly important annotations. Among his original works were, treatises on the "Theory of Comets and Planets"—on the "Armillary Astrolabe"—on "Plane and Spherical Triangles"—and "Ephemerides" for thirty years to come. This distinguished promoter of science was cut off in the prime of life, while making a series of astronomical observations at Rome; and "his early death," (which took place A. D. 1476, in the fortieth year of his age,) "amidst innumerable projects for the advancement of science, is even at this day a matter of regret."

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* Playfair's Dissertat. apud Encyc. Britt.

222. A few names occur in the annals of scientific philosophy, towards the close of the fifteenth century, which it will be sufficient merely to enumerate, since they were far inferior to the two illustrious individuals mentioned above. These were, *Walther,* a citizen of Nuremberg, who attempted to carry on the projects which were left unfinished by Regiomontanus; *Werner,* of the same place, who is said to have been "the first of the moderns that became acquainted with the method of geometrical analysis;" *Benedetto,* an Italian mathematician, who followed in the same track, though with unequal steps; *Bianchini* of Bologna; *Angelo,* a Florentine; *Engelius,* a Bavarian; *Ferdinand* of Cordova, in Spain; and *Bernard* of Granolachi, in the same country. All of these are included in the list of persons who contributed in a greater or less degree to promote mathematical and astronomical science, in different parts of Europe, about the time of the revival of letters.

SECTION IV.

ON THE STATE OF PHYSICAL SCIENCE IN EUROPE DURING THE MIDDLE AGES.

223. THE number of *practical* philosophers (who flourished in Europe during the dark ages) whose names, and the record of whose scientific labours has been preserved, is extremely small. There may have

been many more who silently and without observation prosecuted their favourite studies, at a period in which scholastic subtilties and dialectic disputations were alone the order of the day, and when scientific discoveries were attributed to demoniacal agency and witchcraft. But if there were such, their memory and works have, for the most part, perished amidst the darkness of the age in which it was their unhappiness to live. A few individuals were more fortunate, of whom it is proposed in the present section to give a brief account.

It will be remembered, that, when reviewing the scientific discoveries of the Arabians, mention was made of a celebrated *clepsydra,* or water clock, presented by Al-Haroun to the Emperor Charlemagne. In imitation of this ingenious piece of mechanism, several Europeans, in subsequent ages, exerted their utmost skill and science in the construction of curious automata. Among the earliest of these were, Gerbert (afterwards Pope Sylvester II.), who flourished during the tenth century; and Albert (surnamed the Great), who lived nearly three centuries later. GERBERT spent his youth in the study of the mathematics; but, in more advanced life, he brought his geometrical science to bear on practical physics. Combining theory with mechanical skill, he constructed spheres for astronomical uses; observed the stars through tubes; invented a clock, which marked the hours with tolerable accuracy, and pointed out the courses of the stars; and built an organ, which produced musical sounds, by forcing currents of water with wind through brazen pipes of different length and thickness. These wondrous inventions were more than sufficient, in that age, to procure him the reputation of a magician, and expose him to the hatred of his brethren. ALBERT was the author of numerous treatises on arithmetic, geometry, algebra, astronomy, and mechanics, besides many others on metaphysics, ethics, and scholastic theology. He is said to have chiefly excelled in mechanical science; in proof of which it is stated, that he constructed the automaton figure of a man, who opened the door of the machine in which he was deposited, and uttered certain articulate sounds, as if in reply to questions addressed to him. It is further stated, that the renowned *angelical doctor*, Thomas Aquinas, was so terrified when he heard the vocal sounds uttered by this automaton, as to lift up his staff, and break it in pieces, imagining that he had thereby obtained a signal victory over the Prince of Darkness.

224. The century immediately succeeding that in which Albert flourished, (the 14th,) was yet more favourable to mechanical science. Machines of greater practical utility were then constructed, and applied to the ordinary purposes of life. Among these may be mentioned, as highly important in its consequences, *the invention of paper mills*, attributed to *Ulmar Strame*, a senator of Nuremberg, who flourished about A. D. 1350. The manufacture of clocks, moving by weights and pulleys, is also attributed to this age, though the original inventor is unknown. Of those who excelled in this department of mechanical science, the annals of this

century record with distinguished honour the name of Wallingford, an English monk, who both wrote a scientific treatise on the subject, (still preserved in the Bodleian Library,) and constructed a *chronometer*, that pointed out by its movements the courses of the sun and moon, the state of the tides, with several other curious properties, which were then considered almost miraculous. In imitation of this English phænomenon, an ingenious philosopher of Padua constructed a clock, which marked the hours, the motions of the heavenly bodies, the days, months, and sacred festivals, throughout the year. It is, however, probable, that though constructed on a different principle, both the last-mentioned machines were but imitations of the celebrated clepsydra of Al-Haroun. To Friar Bacon, (whom we shall have occasion repeatedly to mention during our review of the middle ages,) mechanics, as well as almost all other physical sciences, were greatly indebted. Dr. Friend, one of the biographers of that distinguished philosopher, ascribes to him a variety of mechanical contrivances for the rarefaction of air, which probably prepared the way for the important invention of the air-pump; and scruples not to affirm, that Roger Bacon was "the miracle of his age, and possessed perhaps the greatest genius for mechanical science, that has been known since the days of Archimedes."

225. Though this eulogium on Bacon may be somewhat exaggerated, there is no doubt that he stands pre-eminent in one important division of philosophical science, and was most successful in his

discoveries. We refer to his experiments in *optics*, which sufficiently prove the unwearied assiduity with which he pursued the path of true philosophy, in an age of ignorance and gross delusion. No one appears to have preceded him in this track among the philosophers of Europe, except VITELLO of Poland, who flourished about A.D. 1270, and who had made some useful observations and experiments on refracted light, the rainbow, and the human eye. Vitello ascribed the refraction of rays to the resistance which they suffer in passing from a denser to a rarer medium, though he was unable fully to explain the cause, and still less to measure the degree of that resistance. The science of optics was reduced by Vitello to a more regular form than it had previously assumed; general principles were stated and imperfectly established; and tables, shewing the results of experiments on the refractive powers of air, water, and glass, were drawn up by him with great care and accuracy. But Roger Bacon far outstripped his predecessors in this branch of science. It would appear from his writings, that the principle of lenses of various kinds, reflecting mirrors, magnifying glasses, the camera obscura, and many similar inventions, was understood by him; though their practical uses had not yet been discovered. The most important application of lenses to assist vision by the construction of spectacles, some have ascribed to Bacon; but it is generally believed to belong to the close of the century in which he flourished.*

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* Vide "Smith's Optics," p. 80, where the question of the origin of this invention is fully discussed, and the period assigned

226. But though posterity may have been disposed to attach most value to the optical researches and discoveries of Friar Bacon, it is evident, from his own statement, contained in his most celebrated work, entitled "*Opus Majus,*" that he estimated most highly his experiments in *Alchemy*. "His writings on this subject," says a scientific modern author, "though troubled and polluted by the reigning absurdities of alchemy, contain many curious facts and judicious observations. His two principal works were entitled '*Opus Majus,*' and '*Epistola de Secretis Operibus Artis et Naturæ;*' the former of which breathes sentiments which would do honour to the most refined periods of science, and in which many of the advantages likely to be derived from that mode of investigation insisted upon by his great successor (Chancellor Bacon) are anticipated.*"—A striking proof of the justice of this remark has been recently afforded; for Homberg, a celebrated French experimentalist, availing himself of some hints of chemical combinations suggested by Friar Bacon in the thirteenth century, has not long since made some important discoveries in that science. Many proofs might be gathered from the works of this great philosopher, that he was enabled by his penetration and accuracy of experiment to antici-

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to it is A.D. 1313.—Bossut, in his History of Mathematics, affirms, that "the invention of spectacles belongs to the close of the thirteenth century, and that we are indebted for it to the Italians. Incontestable proofs exist, that the first glasses of this kind were constructed by Alexander de Spina, a Jacobin friar, who died at Pisa, in 1313.

* Brande's Dissertation, apud Encyc. Britt. New Sup.

pate the discoveries of subsequent ages. Whatever opinion may be formed respecting the invention of gunpowder, which has wrought such an entire revolution in the art of war, it is certain, that if not actually invented by Roger Bacon, he pointed out the chemical combinations by which it is produced, and described the effects of such combination as causing "an imitation of thunder and lightning." "From saltpetre and other ingredients," he writes, "we are able to form a fire which will burn to any distance." And in another place, "a small portion of matter, about the size of a thumb, properly disposed, will make a tremendous sound and coruscation, by which cities and armies might be destroyed." He also mentions, in another part of the same work, "a substance resembling phosphorus," and which he terms "a fire prepared by art, that cannot be extinguished."

227. From the time of this celebrated experimental philosopher, to that of the revival of letters, scarcely can an individual be pointed out who may claim distinct notice on account of improvements in physical science, if we except those connected with two important discoveries, which must be referred to the period under review, and the influence of which was incalculably great. We allude to the invention of the *mariner's compass* and the *art of printing;* the former of which belongs to the twelfth, and the latter to the fifteenth century.

The remarkable property which the loadstone possesses of attracting iron, seems to have been known to the ancients in very remote ages. But there is no reason to conclude, that the simple fact that a suspended magnet would invariably point to the North Pole, and still less, that the important application of this property of the loadstone to purposes of navigation, was known in Europe before the middle or close of the twelfth century. The French, Italians, Germans, and English, all contend for the honour of this invention. Their claims may perhaps be most equitably adjusted by supposing that, the idea having been once suggested, important improvements in the construction and use of the mariner's compass were almost simultaneously made in several parts of Europe. The value of this discovery (by whomsoever it may have been made) can scarcely be rated too highly; since it has served to remove the barriers by which distant nations were separated, and opened an easy communication, whether for the purposes of commerce, or christian benevolence, between the remotest inhabitants of our globe. New continents have been discovered,—the earth which we inhabit circumnavigated and explored,—the entire dominion of the sea attained,—commerce indefinitely extended,—and wealth, gathered from every region under heaven, accumulated, by means of this felicitous invention. But, we trust, an infinitely more important result of this discovery will yet be seen in the facilities it affords to the universal diffusion of christian knowledge, and the propagation of the gospel throughout the world.

228. The second of the above-mentioned discoveries, viz. the *art of printing*, is yet more im-

portant in itself and in its results. Some have attributed this, as well as the preceding invention, to eastern nations, and have adduced evidence to prove, that the Chinese made use of engraved tablets long before the Christian æra. Without entering into this controversy, or presuming to decide on a question so warmly contested, it will be sufficient briefly to notice in this place its *European origin.* Much obscurity, uncertainty, and contradiction characterise the earliest historical notices of this art. The most probable statement is that which assigns to HAARLEM the honour of having conferred this inestimable benefit on mankind, and attributes to *Laurentius,* a native of that city, of comparatively humble birth, the first rude attempts at printing. He began with carving letters in the rind of beech-trees, and impressing the characters on paper for the instruction or amusement of his grand-children. Next he invented a more glutinous kind of ink than that previously used for MSS., in order that the characters thus impressed might be more distinct and permanent. After this, he cut entire pages in blocks of wood; and finally, he prepared, out of the most solid wood that he could procure, *separate types,* of different sizes and forms. These types are said to have been stolen from Laurentius by one of his servants, (named *Geinsfleiches,* but better known by that of *Faustus,*) who carried them to *Mentz,* and there *privately printed* the first book—"the *Doctrinale,* or Grammar of Alexander Galius"—in 1442. Other accounts, however, state, that Laurentius had previously printed several books, at Haarlem, from his wooden types, between the years 1430 and 1440; among which were the "Speculum Belgicum," and two editions of "Donatus." The next important improvement in this art was the substitution of *metallic* for *wooden* types. These were first made of lead, and soon after of a more solid metal, compounded of tin and lead. It seems probable that the first large work printed with metallic types was the *Vulgate Bible*, published at Mentz, under the auspices of *Gutenberg*, in 1450, after having been seven or eight years in preparation. A third period in the history of the art of printing is that in which *Peter Schoeffer*, of Strasburg, effected a valuable improvement by *casting* metal types, which had been previously *cut* with much labour, and at great expense. The first printed specimen of these improved types was the "*Rationale*," or Logic of *Durandus*, which bears the date of 1459. On account of the three distinct improvements in the art, which have been briefly described, a contest for the honour of its invention arose between *Haarlem*, *Mentz*, and *Strasburg*, which has long since been decided in favour of the former. It is not necessary more minutely to describe the subsequent stages of improvement through which this important art rapidly passed. It constitutes one of the most remarkable features of this invention, that it was perfected almost as soon as discovered; since it is admitted that some of the finest specimens of typography are to be found among the books printed towards the close of the fifteenth century.

CHAPTER III.

THE HISTORY OF INTELLECTUAL SCIENCE DURING THE MIDDLE AGES.

SECTION I.

HISTORY OF LOGIC CONTINUED.

229. THE period, to which the present division of our historical retrospect refers, was chiefly characterised by dialectic subtilties and abstract speculations on metaphysical subjects. This predominant fashion may be traced to a much earlier period than that now under review. It originated with the philosophers of the Eclectic sect, and especially with some christian fathers belonging to the Alexandrian school, who flourished during the second and two following centuries, but whose writings exerted a yet mightier influence after their decease. Among these the most celebrated were, Tertullian, Origen, Clemens Alexandrinus, and Augustine. The three former of these, though eminent scholars, are justly chargeable with the corruption of christianity, by blending with its pure and simple doctrines the speculative refinements of the Platonic philosophy. A taste for metaphysical theology having been thus generated and nurtured, it spread in every direction together with the propagation of the christian faith, and diffused itself through the writings of many of the Latin and Greek fathers. Augustine, Bishop of

Hippo, who flourished about the commencement of the fifth century, contributed in no ordinary degree to the wide and almost universal diffusion of this evil; for such it proved to be in future years, however harmless the speculations might at first appear. His voluminous writings became so celebrated after his death, as almost to supersede every other, and were even deemed by some of the scholastic doctors, (to whom we shall hereafter advert,) a surer standard of orthodoxy, than the writings of the evangelists and apostles. The first distinct treatise on the art of Logic, which properly belongs to the middle ages, was published under the name of Augustine, and long attributed to him, though its spuriousness was afterwards fully proved by some Benedictine monks. This fictitious work, which became so celebrated in the schools, on account of the supposed sanctity and wisdom of its reputed author, was probably the production of some obscure monk, not wholly ignorant of the dialectics of Aristotle, who dexterously availed himself of the superstitions and semibarbarism of the age in which he lived, to give a currency and reputation to his writings, which were by no means due to their merit. It still occupies a place in the first volume of Augustine's works, and consists of two treatises; the first entitled, "*Principia Dialectica;*" the second, "*Categoriæ Decem;*" which were believed to have been translated by Augustine, from the Greek original of Aristotle, into the Latin tongue.

230. It was not, however, till the commencement of the seventh century, that the reign, or rather the

despotism of Aristotle can be considered as fully established. In the earlier ages of the Christian æra, strong prejudices had existed against the Peripatetic philosophy, as more opposed to the doctrines of christianity, than the speculations of Plato and the Academics. But when the defenders of the christian faith perceived the use made by heresiarchs, pagans, and infidels, of the dialectic weapons with which Aristotle had furnished them, and the difficulty of detecting their sophisms, they became convinced of the necessity of providing themselves with like armour of defence and assault. They began, therefore, about this period, to study and admire the dialectics of Aristotle, then lately translated from the Arabic into Latin; to write commentaries upon them of ponderous size; and to employ them as bulwarks for the defence of christian doctrine. Not a few individuals, celebrated in their day, but whose names are now almost forgotten, distinguished themselves by their cumbrous and almost interminable annotations on Aristotle's and Augustine's logic. Among these may be enumerated Photius, Joannes Damascenus, John of Alexandria, Isidore of Seville, Psellus the elder and younger, Eustrathius, Nicephorus, and Magentinus; most of whom wrote commentaries on the works of Aristotle, while some drew up compendia of logic founded on the Peripatetic system. The rise of the Scholastic sect of philosophers (to whom we shall have occasion to advert more particularly in a future section) is chiefly to be attributed to these writings.

231. A new impulse was given to the dialectic art,

towards the close of the seventh and the commencement of the eighth century, by the increased veneration in which *Augustine* was held by the whole christian church, and the lectures which began to be publicly delivered on the manual of logic falsely attributed to him. Several writers of considerable eminence contributed, about this time, to the advancement of intellectual science. Such were,—CAPELLA, a native of Africa, who wrote a work, highly applauded in that benighted age, upon the "*seven arts,*" which were then supposed to embrace the entire circle of human science; namely, grammar, dialectics, geometry, rhetoric, arithmetic, astrology, and music;—CASSIODORUS, author of a similar work, but written in a far superior style, and more methodically arranged;—BOETHIUS, who wrote in Greek, a much admired treatise on "the Consolations of Philosophy," which our Saxon monarch, Alfred the Great, translated into his vernacular dialect;—and CHALCIDIUS, whose commentary on some of the writings of Plato, furnished the speculative metaphysicians of the middle ages with abundant materials for logical debate. Two individuals, who flourished about this period, may claim yet more honourable notice, since they make a distinguished figure in the literary history of our country, and were men far superior to the age in which they lived. These were the venerable BEDE, and ALCUINUS, both of whom were English monks, who, by their writings and instructions, vainly endeavoured to introduce a more just and rational mode of philosophising, than that which then prevailed throughout Europe. Their efforts were, however, completely frustrated, by the blind and bigoted attachment of their contemporaries to the metaphysical subtilties of scholastic theology.*

232. During the ninth and tenth centuries, the rage for dialectic controversies, instead of subsiding, greatly increased. John of Salisbury, who flourished at a somewhat later period, thus characterises the learned men of his day, and the remark will apply to several of the preceding centuries:—"Men at this time," says he, "waste their whole lives in con-

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* The following picture of the literature of that age has been sketched by a modern writer with much fidelity, and may serve to illustrate the general character of the scholastic system of education:—"Even in the most celebrated schools of this age, the field of instruction was confused and barren. In philosophy, nothing was studied but mathematics and logic, and the latter was taught in a trifling and useless manner from the book attributed to Augustine. Neither preceptor nor pupil was at this time to be found who desired or dared to attempt greater things. The circle of instruction, or the *liberal arts*, as the term was then understood, consisted of two branches, the *trivium* and the *quadrivium*. The trivium included grammar, rhetoric, and dialectics;—the quadrivium comprehended music, arithmetic, geometry, and astronomy. These seven heads, which were supposed to include universal knowledge, were thus quaintly expressed in the barbarous Latin of that age:

'*Gramm.* loquitur, *Dia.* vera docet, *Rhet.* verba colorat,
Mus. canit, *Ar.* numerat, *Geo.* ponderat, *Ast.* colit astra.'

He who was master of these was thought to have no need of a preceptor to explain any books, or to solve any questions, which lay within the compass of human reason — the knowledge of the *trivium* having furnished with the key to all language; and that of the *quadrivium* having opened to him the secret laws of nature."—*Enf. Hist. of Philos.* Vol. II. p. 337.

troversy, even disputing in the public streets. When too old for any other employment, they still retain a fondness for debate: always seeking, but never arriving at truth; retailing the opinions and sayings of others, and compiling an incoherent mass of dogmas, out of which each author would find it difficult to recover his own." The names of most celebrity which occur in connexion with this department of letters, (if it may be thus designated,) are, in England, *Joannes Scotus,* surnamed *Erigena, Bridfurth,* and *Dunstan;*—in France, *Maurus, Remigius, Constantine, Hincmar,* and *Abbo;*—in Germany, *Nanno, Herman,* and *Baldric;*—in Spain, *Alfarabi, Avicenna,* and *Averroes;*—and, above all, in Italy, *Gerbert,* (afterwards Pope Sylvester II.) who has already been included in the list of natural philosophers, but who also excelled as an acute dialectician. Had the latter of these luminaries of the tenth century confined himself to the logic of Aristotle, he might have escaped most of the persecutions suffered from his clerical brethren, and would probably have been canonized after his death; but his physical science and skill in mechanics so terrified his ignorant contemporaries, that they ascribed his pre-eminent attainments to satanic agency, and charged him with holding converse with the devil.*

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* A modern historian of the middle ages, concludes his sketch of the varied life of Gerbert, with the following eulogium on his literary character:—"I shall not, I think, be blamed for bringing before the reader the principal events of the life of this extraordinary personage. He has seen him in the different capacities of a scholar and teacher; admired his various attainments;

233. The preceding sketch may serve as a just though brief representation of the state of logical science up to the commencement of the twelfth century, with which the present section will terminate. A few names might be added to the list already enumerated, of men well versed in metaphysical subtilties, and who applied them not to explain but rather to mysticize and obscure the system of christian theology; men who, by means of superior industry, rather than original and inventive genius, raised themselves above the ordinary level of the times in which they lived; but yet who perplexed themselves with fruitless controversies, and expended their strength in unprofitable logomachies. Such were *Ingulph, Lanfranc,* and *Anselm,* in Britain; and *Herman, Berenger, Bruno, Damian,* and *Roscelline,* abroad: some of whom will be more distinctly noticed in the subsequent sketch of the Scholastic Philosophy. To all of these may be applied, though

listened to his eloquence; and followed him as he advanced, through a change of various fortunes, to the zenith of ecclesiastical power. He was certainly an able orator: and his language, though not always pure, yet vigorous and animated, appears, by a pleasing deception, to obliterate for a time the consciousness of the forlorn period in which he lived. Indeed, had it been the fortune of Gerbert to have lived in some more happy æra, his intellectual height would have experienced some diminution. The surrounding shades gave a more striking magnitude to his talents. I must now add, that he was also a poet. Few specimens of his talents in this line have been preserved; but one, not destitute of poetical merit, exists in the form of an epitaph written beneath the portrait of the philosopher Boethius." — *Berington's Lit. Hist. of the Middle Ages*, p. 215.

in various degrees, the character given by Enfield, in his abridgement of Brucker's History, to the learned men of this age generally. "They were wholly employed in attempting to explain abstract notions of theology by terms almost without meaning; hereby accumulating frivolous controversies, and obtruding upon the church new refinements in theological speculations, which soon grew into the monstrous form of the scholastic philosophy." A circumstance, which greatly contributed to this debasement of the art of logic, was, that the dialecticians of those barbarous ages, ignorant for the most part of the Greek tongue, and, consequently, of the original writings of Aristotle, studied dialectics either in the wretched manual of the Pseudo-Augustine, or in defective Latin versions of Aristotle, made from the Saracenic translations of Averroes, Avicenna, Alfarabi, and other Moorish writers, who mutilated the text, and misinterpreted the meaning of their great preceptor. Notwithstanding the labour expended by Herman, Nanno, and a few other scholars of that age, in translating and commenting upon select portions of the genuine writings of Aristotle, it was not till long after this period, that they became more generally known, in consequence of the introduction of copies of the Greek original, into the principal schools and universities of Europe, and the lectures publicly delivered on them by professors of high reputation and learning. — *Vid. Enf. Hist. of Philos.* Vol. II. pp. 350, 351.

SECTION II.

ORIGIN AND GENERAL VIEW OF THE SCHOLASTIC PHILOSOPHY.

234. WE have arrived at that period in the history of the literature of the middle ages, which brings more immediately under our notice that perverted species of intellectual science, which has usually been designated the Scholastic Philosophy. Its origin may be traced to a much earlier period; but it was about the commencement of the twelfth century, that it acquired an ascendancy throughout Europe, to which no parallel can be found in the history either of preceding or subsequent ages. It derives its name from the establishments which had then been recently founded in most parts of Europe, and especially in France, denominated *public schools;* on which account the preceptors were called *schoolmen,* and their course of instruction was described by the general term, *scholastic learning.* One or more of these schools was usually attached to every cathedral and monastery of reputation, to which the youth of distinction repaired for education, and over which presided the acutest logicians of the age. This system, in itself most excellent, and which, at a more enlightened æra, would have been productive of incalculable benefits, soon degenerated into an instrument of papal tyranny and degrading superstition. The public lectures delivered in these boasted seminaries of learning, consisted alone of

verbal subtilties, and absurd speculations, dignified with the name of metaphysical theology. The men who presided over them, though bearing the high-sounding titles of "irrefragable, angelical, seraphic, profound, resolute, and wonderful doctors," were, with a few honourable exceptions, but ignorant, conceited, and pragmatical polemics, versed alone in the artifices and sophisms of a debased logic. They accumulated a prodigious mass of speculative absurdities, which continued during several ages to excite universal admiration. They canvassed and discussed the most thorny and intricate questions in metaphysics, with all the asperity of polemic warfare, and all the pomp of unintelligible language; till every ray of intellectual light was extinguished, and a darkness the most portentous and fearful, brooded over the face of the earth.

235. The following may be enumerated as the more prominent features of the scholastic system of philosophising, when fully developed: (1.) The *topics* selected for the exercise of dialectic prowess, were at once the most abstruse and trifling—the most intricate and absurd. Instead of observing the phænomena of nature, or the operations of the human mind, these sophists were ever in pursuit of occult qualities, latent properties, and imaginary essences;—the creatures of their own bewildered imaginations. "Intention and remission, proportion and degree, infinity, formality, quiddity, individuality, and a thousand other abstract ideas," furnished them with innumerable subjects of speculation, and topics for discussion. The immense

multitude of metaphysical questions most learnedly discussed in the ponderous volumes of scholastic divinity, renders it impracticable to exhibit even an outline of its distinguishing tenets. Suffice it to say, that the metaphysics of Plato, the logic of Aristotle, and the corrupt theology of the church of Rome, were amalgamated into one crude and incoherent mass of unintelligible dogmas, which they honoured with the title of "the orthodox faith;" and the slightest departure from which was esteemed a pernicious heresy.

(2.) In discussing these topics, a most ostentatious display was made of *dialectic skill.* A formidable array was brought forward, of axioms and postulates, lemmas and corrollaries, definitions and syllogisms, arranged in the most systematic form, and employed in exact accordance with the rules of art. "The logic of the schoolmen," says Enfield, "was rather the art of sophistry than that of reasoning, for it was applied to subjects which were not understood, and employed on principles which were not ascertained. Their whole business being disputation, they sought out such thorny questions as were likely to afford sufficient exercise for their ingenuity. Their whole care was to conduct themselves *secundum artem,* and their whole ambition to obtain the victory." The object proposed by these logical prize-fighters, was not so much to elucidate truth, as to bear away the palm from their antagonists; and become celebrated in the schools, as the acutest reasoners of their age. And it must be admitted, that some of the Scholastic philosophers were eminently successful in their object. Champeaux, Abelard, and a few others, displayed an extraordinary degree of talent in this science: by continual exercise, they became skilful adepts in the art of reasoning; prompt, ingenious, and subtle in debate; so as frequently, when discussing the most intricate subjects, to obtain the applause of multitudes, who assembled in the schools, not for instruction, but to witness the triumph or defeat of their respective masters.

(3.) The *language*, in which these abstruse speculations were discussed, whether verbally or in writing, was a species of Latin the most barbarous and debased that can be imagined. Unlike their great preceptor, Aristotle, who wrote even his most technical treatises in pure classical Greek, and embellished some of his most abstruse speculations with rhetorical ornament; the greater part of these *seraphic, angelical doctors*—regardless alike of accuracy and ornament, in violation both of the rules of grammar and rhetoric — introduced a multitude of terms and phrases into the language once spoken by Cicero and Virgil and Livy, which neither they nor any other of the ancient Romans could possibly have comprehended. Nor does this corruption and debasement of the Roman dialect apply only to the more illiterate of these monks, but, with scarcely a single exception, to all the most renowned scholars who flourished during the four last of the *middle* ages.

(4.) Nor must we omit to notice, among the more prominent features of the Scholastic philosophy, the *sectarian acrimony* which it generated. Controversies arose, during the ages under review, which, though they related to unintelligible terms, and mere metaphysical subtilties, agitated the whole of Europe, and gave occasion to the most bitter animosities, and the deadliest hatred. Some of the rival sects will be adverted to in a future section, whose fierce contentions have almost become proverbial; and "the controversy between whom, employed, for many ages, all the ingenuity and learning in Europe; which, therefore, however frivolous in itself, deserves the attention of philosophers, as one of the most curious events which occurs in the history of the human mind." In these metaphysical combats, the sovereigns of Europe and the ministers of state, no less than monks, and prelates, and cardinals, and pontiffs, were involved; and as either sect prevailed, their antagonists became the objects of cruel persecution and malignant revenge. Ludovicus Vives, who lived when some of these sectarian controversies were at their height, has faithfully pourtrayed, though in language too coarse and indelicate to be literally translated, the spirit in which they were carried on, and the disgraceful quarrels to which they led. "I have seen," says he, "the combatants, after having exhausted their stock of verbal abuse, proceed to blows: nor was it uncommon, in these quarrels about metaphysical terms and ideas, which neither party understood, to see the combatants first employing their fists, then their clubs, and, finally, their swords, by which many were wounded and some killed." A more ludicrous species of persecution was exercised by Louis XI. who zealously espoused the cause of the Realists against the Nominalists. That prince, in a royal edict, issued A. D. 1474, not only banished all the Nominalists from his empire, and required the youth educated in the schools to abjure their tenets; but also enjoined that their books should be secured in the monastic libraries with iron chains, so that none might peruse them. Mosheim, in his Ecclesiastical History, asserts, that "the contending sects carried their fury so far as to charge each other with "the sin against the Holy Ghost*;" and that "the celebrated reformer, John Huss, fell a victim to the resentment of the Nominalists; while, on the other hand, the Realists procured, in 1479, the condemnation of John de Wesalia, who had zealously opposed the tenets of their dominant sect.

SECTION III.

BIOGRAPHICAL NOTICES OF THE EARLIEST SCHOLASTIC PHILOSOPHERS.

236. THE rise of the Scholastic philosophy can scarcely be dated further back than the commencement of the eleventh century. Its history has

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[*] Stewart's Elements of the Philosophy of the Human Mind, I. 169, 553, 554. Mosheim's Ch. Hist. Cent. xv. c. ii. § vii.

usually been divided into three periods: the first beginning with Lanfranc, and terminating with Albert, surnamed *the Great;* the second, extending from Albert to Occam; and the third, including the period between Occam and the Reformation; an event which, combined with that of the revival of general literature, completed the destruction of the scholastic system. In the present section, a brief review will be taken of the principal *schoolmen,* who flourished during the first of the above-mentioned periods.

(1.) LANFRANC was born at Pavia, in Italy, and flourished during the greater part of the eleventh century. In his youth, he became celebrated as a distinguished scholar, an eloquent orator, and a profound jurist. But renouncing, in maturer years, these flattering secular pursuits, he embraced the monastic life, and founded a celebrated school at Bec, in Normandy, where many of the most eminent sophists of that age received the elements of their education. So high was his reputation throughout Europe, that multitudes of youth of the highest rank earnestly sought admission into his seminary; and a still greater number attended on his public lectures. The historians of that period dwell with raptures on the erudition of Lanfranc, and the science which long characterized his school. The fame, however, of Lanfranc chiefly rests on his dialectic prowess, and that of his pupils, many of whom excelled their master in the art of disputation. While presiding over this college, he acquired high distinction by the part which he took in a controversy then existing relative to the doctrine of transubstantiation, known in the annals of ecclesiastical history, by the name of the *Berengerian, or Sacramentarian* controversy.* After having educated many eminent scholars at Bec, he was induced, by William of Normandy, (who had then recently obtained the English crown,) to relinquish his literary retirement, and become Primate of England. He was consecrated Archbishop of Canterbury, in 1070, and died A. D. 1089. Lanfranc was the author of numerous treatises, chiefly on subjects connected with polemic theology, though some were of a more literary character, and all are celebrated for the comparative purity of their Latin style.

(2.) BERENGER, of Cologne, who is chiefly celebrated as the originating cause of the famous controversy on the Eucharist, which agitated Europe at the commencement of the eleventh century; *Fulbert,* Bishop of Chartres, under whom Berenger had studied logic and metaphysics; and *Bruno,* a pupil of Berenger, and founder of the Carthusian order of monks; all were distinguished ornaments of the Gallican church, and masters of the dialectic art, at a period in which logic was deemed the highest attainment of human genius. Their writings are now almost forgotten, though they are said to have been characterised by great subtilty of reasoning, and many ingenious speculations.

(3.) ANSELM, a name familiar to every reader of English history, ranks high among those who received their education at Bec, under Lanfranc; and, like his preceptor, was remarkable for the application of dialectic rules to the most profound subjects of metaphysical research, and the minutest distinctions of polemic theology. A considerable change was effected by the public lectures and writings of Anselm, which has been thus characterised by an intelligent modern historian:—"Logic, which, agreeably to its primitive acceptation, denoted the art of just and solid reasoning, had degenerated into verbal controversies, the terms of which were unintelligible even to those who employed them. But Lanfranc and Anselm, by the greater purity of their style and perspicuity of their reasonings, introduced an important change into the philosophy of their age, especially in the departments of logic and metaphysics." Anselm composed a treatise entitled "*The Grammarian,*" which was in reality, a practical dissertation on logic. He was also the author of two works on metaphysical theology, entitled *Monologion* and *Prosologion,* from which even modern polemics might derive some advantage. He succeeded Lanfranc in the presidency of the college of Bec, A. D. 1070; became abbot of the adjoining monastery in 1078; was elevated to the primacy of the English church in 1093, and died A. D. 1109. This celebrated ecclesiastic contributed more by his metaphysical abstractions towards the establishment of the Scholastic philosophy, than any of his contemporaries.*

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* Vid. Dupin's Ch. Hist. 11th Cent. Mosheim's Ibid.

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* "Before these two great men opened their schools," say the authors of the Literary History of France, "the Latin spoken

(4.) ROSCELLINE flourished towards the close of the eleventh century, and is chiefly celebrated as the founder of the sect of the *Nominalists*,* which afterwards became famous under the auspices of his more illustrious pupils. Of himself little is known, except that he was a native of Brittany, and canon of Compeigne; that he was acknowledged, even by his adversaries, to have possessed an acute and subtle genius; and that by him certain innovations were introduced into the philosophical speculations of that age, which obtained a wide and rapid circulation after his death.

(5.) CHAMPEAUX, Bishop of Catalan or Chalons, was a contemporary of Roscelline, but attached to the opposite sect of the *Realists*,* whose opinions

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in France was rude and barbarous---their philosophy was not worthy of the name; and their theology was lifeless and void of precision. When they began to speak and write, a wonderful change ensued. Lanfranc taught the use of those arms in defence of christian belief, which theology supplies: his pupil Anselm undertook the solution of questions, which, before his time, were involved in darkness; and shewing the conformity of his decisions with the authority of scripture, taught his disciples, by a new method of argumentation, to reconcile reason with faith, while he directed philosophy to pursue the path of patient investigation."—*Berington's Lit. Hist.* p. 261.

* Of these two celebrated sects, it will be sufficient to state here, that the *Nominalists* were so called, because they maintained that there are no real existences in nature corresponding to general terms, and that the objects of our attention in all abstract general speculations are not *ideas* but *words*. The *Realists* held that all individuals partake of the essence of their species, and are only modified by accidental causes, while their real essence remains unchanged. The question between them may be otherwise stated thus,—"whether universals have a real

on the abstruse metaphysical question to which that controversy referred, he defended with the utmost zeal in the public schools of Paris. But both he and Roscelline owe more of their celebrity to their having been, at different periods, the preceptors of Abelard, than to their own writings, or their public disputations.

(6.) ABELARD, the well-known founder of the *Paraclete* monastery, alike celebrated for his talents and his misfortunes, was born at Palais in Bretagne, A. D. 1079. His first preceptor was Roscelline, from whom he imbibed those metaphysical opinions to which he stedfastly adhered through life, and which indeed derived their principal lustre from his unrivalled talents and learning. He subsequently studied dialectics under William de Champeaux, but made an ungracious return for the instructions received from his venerable preceptor, by entering the lists with him in the public schools, and vanquishing him in several public disputations. Having thus acquired the reputation of an universal champion in scholastic theology, he established flourishing seminaries of learning, first at Melun, and afterwards at Corbeil, near Paris, where he lectured publicly on logic and metaphysics to immense multitudes, and with the utmost applause. But the boldness of his speculations, and his high scholastic fame, soon raised him up hosts of adversaries, by whom he was denounced to the papal see as here-

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and essential, or only a nominal and verbal existence in individuals." The Realists contended for the former, the Nominalists for the latter of these hypotheses.

tical; and who continued to harass him with ceaseless persecutions to the end of his days. He was the author of many treatises on subjects connected with the philosophy of that age, which have never been edited, though far superior to the mass of the scholastic writings, and indicating both greater refinement of taste and extent of erudition. A single volume has been published, entitled "Christian Theology," which is characterised both by the acuteness and absurdity of the scholastic system. Abelard died at the monastery of St. Marcellus, at Chalons, A. D. 1142, and was interred in the convent of the Paraclete.

(7.) PETER LOMBARD, who studied theology and logic under Abelard, rivalled him both in dialectic subtilty and polemic zeal. He was a native of Lombardy, and became Archbishop of Paris, A. D. 1151. During his life, and long after his death, he was known by the title of "*Magister Sententiarum*," on account of a work compiled by him, consisting of sentences extracted from the fathers, and questions for disputation. This became a standard book of high reputation in the theological schools, and was honoured with numerous commentaries. "When the *Book of Sentences* appeared, says a modern historian, it was received with universal approbation, and its authority soon became so great in all the schools, that it was deemed inferior to none but the inspired writings. He who, in the discussion of any question, did not reason from the *Master*, reasoned in vain; and men of the first talents could not employ them, it was thought, more worthily, than in expounding or illustrating what the Master had delivered." *Berington's Lit. Hist.*

(8.) To the preceding Scholastics, all of whom belonged primarily to the Gallic church, may be added GILBERT DE PORRETAN, Bishop of Poictiers, who, though deemed heretical by the rulers of the Roman-catholic Church, was unquestionably a keen and subtle disputant. To him are attributed many of the scholastic phrases, which afterwards became current among the sophists of that age, and numerous subtle theological distinctions, unintelligible alike to himself and his readers. Having presumed, in his writings, to maintain that "a distinction exists between *nature* and *person*, and that the essence of God is not God himself," with other cobweb refinements of a similar kind, he was denounced by the famous Bernard, (at that time the great champion of papal orthodoxy,) as a dangerous heretic, deprived for a time of his ecclesiastical dignities, compelled to retract his errors, and his books were publicly burnt. He contrived, however, to make his peace with the church, and was restored to his episcopal see, a short time before his death, which took place A. D. 1154.

(9.) *John of Salisbury*, though usually classed with the Scholastics of this age, rises far above them in true wisdom and useful learning. He was not only a skilful dialectician, but also a considerable linguist, a proficient in physical science, and a faithful historian of his own times. He studied at Paris under Abelard, and imbibed from that celebrated master, a taste for philosophy and science. He was the intimate friend of Thomas à Becket, by whom he was patronized in prosperity, and whom he afterwards accompanied in his exile. To this impartial writer we are indebted for the most faithful portraiture of the learned men of his own age, whom he describes as "exhibiting the semblance, rather than the essence of knowledge; as designedly rendering their disputations obscure, that they might obtain the greater credit for wisdom; and as frequently confounding, through ignorance, the Peripatetic and Platonic systems, while they professed the utmost veneration for Aristotle; and, finally, notwithstanding their high pretensions to learning, as not having contributed an iota towards the advancement of true science." The principal works of John of Salisbury were, his *Metalogicon*, which contained treatises on grammar, philology, and the logic of Aristotle; and his *Policraticon*, which gives a lively description of the manners of the age, boldly censures the vices of the great, and exposes the ignorance and ambition of the ecclesiastical orders. Of this work, a competent witness in modern times has given the following character:—"When I read some years ago," says Berington, in his Literary History of the Middle Ages, "the Polycraticon, it seemed to display great erudition, and to be replete with moral notions, sentences, passages of authors, examples, apologues, extracts of history, common-places and citations from the best classical writers. But it appeared to be an ill-digested mass of learning, neither directed by a sound judgment nor embellished by taste. Notwithstanding its imperfections, it is a valuable monument of literature; and exhibits, in a pleasing manner, the talents, the good sense, and the learning of John of Salisbury."

(10.) The last of the Scholastics of the first period, whom it is requisite to mention distinctly, was HALES, Abbot of Glocester, who was dignified with the high-sounding title of "*the irrefragable doctor*." He also was one of the disciples of Abelard at Paris, and became celebrated for his skill in metaphysical theology. He wrote commentaries on the "Book of Sentences" of Peter Lombard, and on the "Metaphysics of Aristotle," much admired at the time for their reputed ingenuity and learning, but long since buried in oblivion.

SECTION IV.

SCHOLASTICS OF THE MIDDLE PERIOD.

237. THE second or middle period of the history of scholasticism may be considered as commencing with the thirteenth century, when a considerable number of the most renowned advocates of that system simultaneously laboured with incredible zeal and diligence for its advancement. To a few of these it will be requisite to advert in this place, whose celebrity, when living, and long after their death, attaches an importance to their name and memory, to which otherwise neither their learning nor talents could have entitled them.

(1.) **Albert**, surnamed *the Great*, (who has been already classed with the scientific philosophers of the middle ages, on account of his mechanical skill,) was chiefly indebted to his logical science and polemic zeal for his living and posthumous fame. He was born in Swabia, A. D. 1193; became a dominican friar when about thirty years of age; and was subsequently employed in teaching philosophy at the public schools of Cologne and Paris, or in writing ponderous volumes on abstract metaphysical speculations, till his death, which took place A. D. 1280. This indefatigable author wrote on an almost endless variety of subjects, as appears from his works, which were collected and published after his death in no less than twenty-one folio volumes, including treatises on theology, ethics, metaphysics, logic, natural philosophy, natural history, and the mathematics. He seems to have traversed the whole circle of theological, moral, intellectual, and physical science. If the value of Albert's writings could be estimated by their number or magnitude, he must be acknowledged to have been no ordinary contributor to the stores of general knowledge: but the history of the period under review goes far to prove that the estimate must be taken in an inverse ratio, and that in proportion as the writings were voluminous, they were trifling and useless. The portion of the works of Albert, which alone can be regarded with interest in modern times, is that which relates to practical and experimental philosophy. From him arose the sect of the Albertines, frequently alluded to by the ecclesiastical historians of that age.

(2.) Bonaventure ranks high in scholastic fame, and was honoured with the title of "*the seraphic doctor*," on account of the ardour of his devotion to the Virgin Mary. He was born in Tuscany, A.D. 1221;—studied theology and logic under Hales;—graduated at Paris;—and became Franciscan friar at the same time with his renowned contemporary, Thomas Aquinas. He was created Cardinal by Pope Gregory; and died while attending the second general council of Lyons, A.D. 1279. The most remarkable of his productions was, "A Dissertation on the application of the Arts to Theology, " which affords," says Enfield, " a curious specimen of the manner in which the mystical divines of that age transferred the Scholastic philosophy to theology."

(3.) But the chief glory of the Scholastic age was the *illustrious* Thomas Aquinas, to whom his contemporaries and idolaters, with one consent, awarded the title of "*the angelical doctor*." This prodigy of learning, as he was generally considered, was born of a noble family at Aquino, in Italy, A.D. 1224, educated first in the monastery of Mount Cassino, then at Naples, and finally at Paris, under Albert the Great. He subsequently became theological lecturer of Cologne, Paris, and Rome. So extravagant were the encomia passed upon him by his ignorant and superstitious devotees, that some supposed him to have inherited the soul of Augustine, others of Aristotle, and some even of St. Peter himself. With a slender knowledge of the Greek and Arabic tongues, he contrived to pass for a prodigy of learning in a dark age; and by dexterously blending the Peripatetic and Eclectic systems of philosophy with the reasoning of the Greek and Latin fathers, he gained the reputation of a profound theologian. His most celebrated writings are, "The Sum of Theology," in which a great variety of trifling and absurd questions in metaphysical theology are most gravely and learnedly discussed; his "Commentary on P. Lombard's *Book of Sentences;*" and "Annotations on the *Analytics, Metaphysics,* and *Ethics of Aristotle.*" Speculative philosophy was the only element in which Aquinas could breathe; but all physical science was either despised by him as useless, or denounced as the result of necromancy and witchcraft. This phænomenon suddenly disappeared in the midst of its glory, and whilst all Europe was gazing with an admiration little short of idolatry upon the splendour of its intellectual course. This celebrated Scholastic theologian died in the fiftieth year of his age, while on his way to the council of Lyons, which was held A. D. 1279.

(4.) Contemporary with Bonaventure and Aquinas, who belonged to the Italian and French schools of philosophy, were two of the English school, who, if not equal in fame, were far superior in general and useful knowledge. These were *Grostèste,* (or *Greathead,*) Bishop of Lincoln, and *Roger Bacon,* the father of English philosophy. Though both of these are usually classed with the Scholastics, their science and erudition may justly entitle them to a more venerable station in the republic of letters. Having before alluded particularly to Friar BACON, it is now unnecessary to say more respecting him, than that much of his attention was given, and many of his posthumous works relate, to intellectual as well as physical science, though the latter was his favourite study. He applied himself diligently to the acquisition of the Greek and Hebrew languages, then very imperfectly known even to the best scholars. He prepared, in the retirement of his monastic cell, erudite works on history, jurisprudence, dialectic and metaphysical theology, as well as on mathematical and physical subjects. The literary history of *Grostèste* is less known, though he occupies a distinguished place in the ecclesiastical history of our country. His celebrity is partly founded on the strenuous opposition made by him to the encroachments of the Roman pontiff, and partly on the testimony of Roger Bacon to his genius and learning, who, though usually parsimonious of praise, and much more inclined to censure than to eulogise his contemporaries, classes him with "Aristotle and Solomon," and describes him as "the only learned man of his age." Some of his works were mathematical, others critical; but the greater portion consists of philosophical and theological tracts. It may be particularly mentioned to the honour of this pious and learned prelate, that while the *seraphic* and *angelic doctors* were laboriously employed in writing commentaries on Peter Lombard, or Augustine, Grostèste was employed in scriptural researches, and in diligent study of the Hebrew and Greek original texts, that he might be the better enabled to comprehend and interpret the sacred writings. Grostèste, like his celebrated countryman and contemporary, Roger Bacon, was far too enlightened for the age in which he lived; both were charged with necromancy, and suffered persecution on this account; and both became objects of jealousy to the ecclesiastical authorities of the church of Rome. He died A.D. 1253.

(5.) Passing once more to Paris, which was the strong hold of scholasticism at this period, we meet with COLUMNA, an Italian by birth, and monk of the Augustine order, who was preceptor to the sons of Philip III. of France, and taught philosophy and theology in the university of Paris with so great reputation, as to acquire the title of "*most profound doctor*." If his real character as a philosopher corresponded with the inscription upon his tomb, denoting that "he was a luminary who brought light out of darkness," he must have differed widely from the rest of his scholastic brethren; but as far as his writings are now known, they utterly discredit the testimony of his sepulchral monument, for they are amongst the most obscure productions of that age of intellectual darkness. In connexion with Columna may be mentioned *Robert de Sorbonne,* who also flourished about the middle of the thirteenth century. He was an acute and distinguished logician; but is better known as the founder of the theological college at Paris, which still continues to bear his name.

(6.) Towards the close of the thirteenth century, flourished at Oxford and Paris, DUNS SCOTUS, the pupil and rival in scholastic fame of Thomas Aquinas. He was designated "*the most subtile doctor*," on account of his acuteness and subtilty in disputation. His reputation at one period of his life (the whole of which was short, for he died in his thirty-fourth year,) was such, that not less than thirty thousand youths are said to have flocked from all parts of Europe to attend his public lectures. His works, when collected, amounted to twelve folio volumes. But he is chiefly known as the founder of a new sect among the Scholastics of the thirteenth and fourteenth centuries, known by the name of the *Scotists,* in distinction from the *Thomists,* who adhered to the opinions of Thomas Aquinas. The difference between these rival and hostile sects related to some abstruse points of metaphysical divinity, into which it is not our present business to enter. "The ingenuity of Duns Scotus," says Enfield, "was wholly employed in embarrassing with new fictions of abstraction, and with other scholastic distinctions, subjects already sufficiently perplexed."

The above list of Scholastics of the middle period, might easily be enlarged; but little advantage could result from the mere enumeration of names deservedly forgotten; or a transient reference to works, which, though indicative of great labour, tended rather to obscure than enlighten the human understanding.

SECTION V.

SCHOLASTICS OF THE THIRD PERIOD.

238. THE portion of the history of Scholasticism, which was rapidly traversed in the last section, includes that of its greatest prosperity. It had then attained its highest elevation, and exercised a despotism over the understandings of men, almost as oppressive as that which the papal hierarchy had long usurped over their religious faith and practice. But during the period now to be reviewed, its power was shaken, its influence gradually diminished, and the struggle commenced which terminated in its destruction. There were still many, who remained servilely attached to the logic of Aristotle and the sophistry of the schools. Perhaps there was never a period in which the Peripatetic philosophy was more dominant. The reverence for the writings of Aristotle was so great, that no more direct road to scholastic fame could be devised than that of delivering public lectures, or writing commentaries on parts of these ancient documents; and, in some instances, they were even read in public during divine worship, instead of the pages of inspiration. A long train of schoolmen might be brought forward, who flourished during the thirteenth and fourteenth centuries, who spent all their days in poring over the "categories or analytics," which had become the more celebrated, now that their Greek originals were known, and Grecian literature had revived. But amidst all, indications were not want-

ing of the approach of a happier æra. Light began to dawn, though faintly, on several parts of Europe. In *Italy*, a taste for classical literature began to revive under the auspices of a few ardent scholars, and a small band of illustrious patrons of learning. In *England*, Wickliffe aimed an effectual blow at the Scholastic system, by his theological writings, and especially by his venerable translation of the Scriptures. In *France*, the sect of the Nominalists, which had languished from the time of Abelard, revived, and with it a freedom of inquiry and independence of speech and writing, which led to the most important consequences. This was chiefly effected by *Durand* and *Occam*, who were contemporaries, and in part coadjutors, in the work.

(1.) OCCAM was educated at Oxford, under Duns Scotus; but after the death of his preceptor, he renounced the sect of the Realists, and revived that of the Nominalists, though under a new name. His followers assumed the title of Occamists, to avoid the odium which then attached to the opinions of Roscelline and Abelard, and honoured their master with the appellation of "*the invincible doctor*," on account of the tenacity with which he maintained, and the splendid success with which he defended, his philosophical opinions. It required, at that period, no common degree of moral heroism to lift up a standard against the opinions of such men as Aquinas and Albert and Scotus, and dispute their authority, even on the most abstruse metaphysical questions. This offence might, however, have been forgiven, had not Occam proceeded farther, and assailed the *Colossus* of papal power, and exposed the indolence, the ignorance, and the profligacy, of the monastic orders. Having directed his attention to jurisprudence, he wrote several tracts on "Civil and Ecclesiastical Law;" the object of which was, to define their respective boundaries, and point out their legitimate authority. These treatises, though written, after the fashion of that age, in barbarous Latin, and in a dry systematic manner, produced a strong sensation throughout the Roman church, and excited the utmost alarm. Their author was required to retract his errors; and on his refusing to do this, was excommunicated. Besides these, his more valuable writings, (valuable, as having contributed, in some degree, to shake the throne of papal supremacy, and prepare the way for the Protestant Reformation,) Occam was the author of several dialectic treatises on the "Predicables of Porphyry, and the Categories of Aristotle," and of numerous controversial pieces in defence of the opinions of the Nominalists.

(2.) Durand was a native of Clermont, who taught logic and metaphysics in the university of Paris, in the earlier part of his life; and was subsequently elevated to the bishopric of Meaux. He zealously espoused the cause of the *Scotists*, in opposition to the followers of Thomas Aquinas. His public lectures and writings were characterized by a boldness and independence that procured for him the title of "*most resolute doctor*." "He took," says Dupin, in his Ecclesiastical History of this period, "from former philosophers what he thought proper, without tying himself down to the principles of any, and advanced many new opinions. After him the divines took more liberty, and many novel systems were invented."

(3.) *Burley*, who was surnamed, though for what reason it is difficult to conjecture, "*the perspicuous doctor*," was preceptor to Edward III. of England, and one of the most renowned Scholastics of his age. He wrote, on ethics, physics, logic, metaphysics, and theology, works which have long since been forgotten. The treatise which is best known is, that on the "Lives and Manners of the Ancient Philosophers," into which were introduced, biographical notices of all the Greek and Roman philosophers, from Thales to Seneca.

(4.) *Raymond Lully*, flourished somewhat earlier than either of the above-mentioned Scholastics, but is usually classed with them, on account of the novelty of his opinions, and his unwearied and persevering efforts to introduce into the schools a new method of philosophizing. This "*most enlightened doctor*," (for such was the distinctive appellation given to him by the schoolmen,) is said to have greatly excelled in chemistry and medicine; but his fame chiefly rests on his celebrated invention, known by the name of the "*Great Art*," which professed to furnish adequate means for the attainment of every species of science in its highest degree. The proficients in this art were to be enabled thereby to invent arguments, *mechanically*, on all kinds of topics, but especially on all connected with logic, metaphysics, and theology. Perhaps the whole history of mankind does not furnish an instance of greater absurdity under the veil of profound science, than that of the mechanical logic of this fanatic. Yet, such was the ignorance and credulity of the age in which this boasted invention was promulgated, that it is celebrated by most of the historians, as one of the proudest efforts of human genius, placing its inventor on a level with the greatest philosophers of antiquity.

239. If it were the design of this work to trace the progess of *general literature,* its writer would dwell with pleasure on the aspect which Italy presented during the greater part of the fourteenth century. He would record the munificent patronage of the princes of the house of Medici—the ardent and unwearied labours of Petrarca, Boccacio, Poggio Bracciolini, and others, in exploring the monastic libraries, and bringing thence the most valuable remains of classical antiquity,—or the useful exertions of a literary band of exiled Greeks, who, driven from their own country by the calamities of war, settled in Italy, and diligently employed themselves either in the collation of Greek MSS. or translating them into a Latin dialect, far superior to that which prevailed in the schools. These, however reluctantly, we must pass over, as falling without the prescribed line of this elementary work. Those individuals among them can alone be selected, who contributed to the revival, if not the advancement of intellectual science. Among these, the justly celebrated PETRARCA stands preeminent; who flourished about the middle of the fourteenth

century. Though chiefly known to posterity as a man of taste and letters, he occupies no mean place among the philosophers of his age. His ethical writings have been greatly admired, both for the purity of their style, and the comparative excellence of their sentiments. It is a most grateful change to the intellectual inquirer, after having been wearied with the frivolous and unintelligible logomachies of the schoolmen, to meet with essays on subjects connected with true philosophy; such as "the contempt of the world,"—"the remedies of fortune," or, "the dangers of self-ignorance." *Argyropulus*, a native of Constantinople, patronised by the house of Medici, and his fellow countryman, *Chrysoloras*, with many others of inferior reputation who might be enumerated, rendered important services to philosophy, by their translations of the recently discovered remains of the Grecian philosophers, and their *critical* commentaries on the works of Plato, Aristotle, and Epicurus.

PART III.

THE HISTORY OF PHILOSOPHY & SCIENCE,

CONTINUED FROM THE REVIVAL OF LETTERS TO THE CLOSE OF THE SEVENTEENTH CENTURY.

CHAPTER I.

INTRODUCTORY.

SECT. I.

ON THE CAUSES OF THE REVIVAL OF LETTERS.

240. We may at length congratulate ourselves on having crossed the *great desert,* which occupies so large a space in the chart of human science, and reached the borders of a region characterized by an extraordinary degree of intellectual luxuriance and fruitfulness. As it is grateful, after a long wintry night, to observe the earliest indications of dawning day, so, in emerging from the darkness of the middle ages, is it most cheering to the intellectual enquirer, to fix his eye on some of those morning stars of genius, which afforded a sure presage, that the sun of science was about to arise and shine upon the earth. The analogy may be traced one step further. As in the physical world we do not perceive a sudden and immediate transition from midnight

darkness to the splendour of noon-day, or from the dreary barrenness of the desert to the richest verdure and most abundant fruitfulness; so neither can we expect, in passing from the review of ages characterised by sterility and mental darkness, to be dazzled at once with the lustre of pre-eminent genius, or to reap the full harvest of physical and moral science. Yet, imperfect as their first attempts, and limited as their attainments may have been, who first rent asunder the fetters of ignorance, and contributed to the dispersion of intellectual darkness, they are by no means to be overlooked, nor should their labours be lightly esteemed.

241. It is an interesting object of inquiry, "what were the *causes* which cooperated to effect the emancipation of the human mind from the thraldom in which it had been held, and who were the distinguished individuals by whose instrumentality it was effected ?" To this inquiry it will be attempted, in the present section, to furnish a brief reply. The principal causes of the revival of letters, which took place towards the close of the fifteenth century, may be classed under three general heads—*political*, *literary*, and *moral*. In adverting to these, it may be requisite to pass over some of the ground which has been already trodden; but perhaps this is not to be regretted, since it may serve to impress more deeply on the memory, facts which in themselves were highly important, and in their results have proved incalculably beneficial.

(1.) Among the political causes of this intellectual phænomenon may be enumerated, the fall of the eastern empire, and the conquest of Turkey and Greece by the Saracens; the effect of which was to disperse the men of learning, who resided in those provinces, through the continent of Europe, but more especially to enlighten those countries which lay contiguous to the Ottoman empire,—the gradual demolition of the feudal system, and consequent elevation of the lower orders of society to wealth and importance,—the study and practice of jurisprudence, by which the administration of justice was secured, and civilization promoted,—the intolerable oppression of the papal hierarchy, which, though tamely submitted to during many ages, at length became so galling a yoke, that both princes and their subjects stood prepared to shake it off,—and, finally, the consolidation of the civil governments of Europe, under the administration of more enlightened princes, who became the zealous patrons of learning and science.

242. (2.) On the *literary* causes of this important change in the aspect and condition of society, it will be proper to enter somewhat more into detail. The first, and perhaps the greatest of these, was the invention of the *art of printing*, a brief history of which has been already given. Circumstanced as we now are, it is not easy to conceive of the mighty impulse which this valuable discovery must have given to the operations of the human mind. " For us, (says Stewart, in his admirable Dissertation on the Progress of Mental Philosophy, to which we shall have frequent occasion to refer in subsequent pages,)—" for us, who have been accus-

tomed, from our infancy, to the use of books, it is not easy to form an adequate idea of the disadvantages which those laboured under, who had to acquire the whole of their knowledge through the medium of universities and schools; blindly devoted, as the generality of students must then have been, to the peculiar opinions of the teacher, who first unfolded to their curiosity the treasures of literature and the wonders of science. Thus error was perpetuated; and, instead of yielding to time, acquired additional influence in each succeeding generation. But the art of printing, by rendering the *taught* less dependent on their *teachers*, and by opening more widely the sources of knowledge, served quickly to break down these ancient barriers, and emancipated the human mind from its bondage."—*Stewart's Dissert. ut sup.* pp. 24, 25.

The next cause of the revival of letters, at the period under review, which may be properly termed *literary*, was, the discovery, and, by means of the art of printing, the easy and rapid distribution of those stores of ancient learning, which had been for many ages immured in monastic libraries, and were scarcely known to exist; and, in connexion with this, the arrival in Italy, and other parts of Europe, of a considerable number of learned Greeks, formerly resident at Constantinople, who assiduously and honourably employed themselves in unfolding the treasures of Grecian literature by means of Latin versions. This awakened the attention of European scholars to the importance of obtaining a critical acquaintance with the Greek tongue, and at the same time afforded them every facility they could desire. The former of these incentives to literary exertion, was furnished by the generous enthusiasm of such men as Petrarca, Boccacio, and Poggio Bracciolini; the latter, by the indefatigable labours of Chrysoloras, Argyropulus, Pletho, Theodore Gaza, Lascario, Bessarion, Trebizond, with many others.

A third cause, which cooperated with those just enumerated to produce this happy result, was, the existence, at that period, of a few distinguished individuals, who were insatiable in their thirst for knowledge, and who could no longer be content to follow the dull routine of dialectics and metaphysics, hitherto exclusively taught in the schools. These persons were men of letters, rather than philosophers. Their talents were chiefly directed to the critical investigation of the classical writings of antiquity then recently brought into notice, and their great object was to revive a taste for the study of Roman and Grecian literature. They laboured, therefore, with incredible assiduity, in the department of philology, and substituted the rules of criticism for the subtilties of scholastic logic and metaphysical theology. This taste, which characterised, in a great measure, the writings of the fifteenth and sixteenth centuries, was generated and nurtured by the personal influence and successful labours of those distinguished scholars enumerated above; to whom might be added, Erasmus, Ludovicus Vives, Melancthon, Budæus, William de Wykeham, Sir Thomas More, with many others, who will be more distinctly noticed hereafter.

243. (3.) Among the *moral* causes, which operated most powerfully to subvert the authority of the schoolmen, as well as to effect a yet more important revolution in the opinions of mankind, the principal was *the Reformation from Popery.* It forms no part of our present design to investigate the causes or trace the progress of the Protestant Reformation; a subject which belongs more properly to ecclesiastical history than to that of philosophy and science. At present, it is only contemplated as exerting a mighty and resistless influence on the intellectual attainments and pursuits, not only of the Reformers themselves, but indirectly and more remotely on the general mass of society. "The renunciation," says Stewart, "in a great part of Europe, of theological opinions so long consecrated by time, and the adoption of a creed more pure in its principles and more liberal in its spirit, could not fail to encourage, on all other subjects, a congenial freedom of inquiry. These circumstances operated still more directly and powerfully by their influence in undermining the authority of Aristotle; an authority, which, for many years, was scarcely inferior to that of the Scriptures, and which, in some universities, was supported by statutes, requiring the teachers to promise upon oath, that in their public lectures they would follow no other guide."* The keen satire of Erasmus, the tremendous thunders of the Saxon Reformer, the mild philosophical reasonings of Melancthon, contributed, though in different degrees, and by widely different

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* Stewart's Diss. p. 23.

methods, to the same valuable end. They taught men to think, to reason, and to judge for themselves. They substituted the authority of truth for that of ancient tradition and venerated names. They inculcated, both by precept and example, the duty of "proving all things, and holding fast that which is good."

SECTION II.

CLASSIFICATION OF INTELLECTUAL AND SCIENTIFIC PHILOSOPHERS OF THE 16TH & 17TH CENTURIES.

244. FOLLOWING the arrangement which has been adopted in the former divisions of this work, previously to a cursory review of the scientific discoveries and philosophical researches which shed a lustre on the sixteenth and seventeenth centuries, a general classification will be attempted of the individuals engaged in these pursuits. In doing this, it is evident that a selection is necessary; for the arena becomes so thronged, as we proceed, that it would be scarcely possible even to enumerate, and much less to sketch, the literary history of all who contributed to the advancement of science. The principle on which that selection will be made, is that of noticing exclusively those, who, either by the pre-eminence of their genius, or by the fame of their writings, or by some specific discovery in philosophy or science, acquired, and justly merit, an honourable distinction. The following tables will exhibit, at one view, the persons who flourished in each of the above-mentioned centuries, and the department in

which they principally excelled. A few names, it will be perceived, occur in both lists, because they may, with equal propriety, be classed with the scientific and intellectual philosophers of their age.

I.—SCIENTIFIC PHILOSOPHERS,

From 1450 *to* 1600.

NAME.	COUNTRY.	BORN.	DIED.
Baptista Porta	Naples	1445	1515
Werner	Nuremberg	1468	1528
Copernicus	Thorn, in Prussia	1472	1543
Nonius	Alcazar, Portugal	1492	1577
Maurolycus	Messina, in Sicily	1494	1575
Cardan	Milan	1501	1575
Tartaglia	Brescia	——	——
Fernel	Paris	1506	1558
Commandine	Urbino	1509	1575
Reinhold	Wirtemberg	1511	1553
Ramus	Picardy	1515	1572
Stiphelius	Nuremberg	(*fl.* 1550)	
Bombelli	Bologna	(*ibid.* 1579)	
Vieta	Fontenoy	1540	1603
Tycho Brahe	Knudstorp, in Denmark	1546	1601
Napier	Marchiston, in Scotland	1550	1616
Ubaldi	Italy	1553	1617
H. Briggs	Halifax	1556	1630
Albert Girard	Flanders	——	1634
Harriott	Oxford	1560	1621
Bacon (Lord Verulam)	London	1561	1626
Galileo	Florence	1564	1642
Antoni D. Dominis	Archbishop of Spalatio	——	1625
Kepler	Wirtemberg	1571	1630
Gregory St. Vincent	Netherlands	1584	1667
Fermat	Toulouse	1590	1664
Snellius	Leyden	(*fl.* 1617)	
Gassendi	Provence	1592	1655
Des Cartes	Touraine	1596	1650
Riccioli	Ferrara	1598	1671
Cavalleri	Milan	1598	——
Stevinus	Flanders	(*fl.* 1586—1635)	
Castelli	Italy	(*fl.* 1628)	

II.—SCIENTIFIC PHILOSOPHERS,

From 1600 *to* 1700.

NAME.	COUNTRY.	BORN.	DIED.
Toricelli	Italy	1608	1647
Roberval	France	(*fl.* 1646)	
Hevelius	Dantzic	1611	1687
Mercator	Holstein	1616	1688
Wallis	Ashford, in Kent	1616	1703
Ward	Buntingford	1617	1662
Horrox	Texteth, in Lancashire	1619	1640
Otto Guerické	Magdeburg	(*fl.* 1654)	
Marriotte	Burgundy	——	1684
Brouncker	Castle Lyons	1620	1684
Pascal (Blaise)	Claremont	1623	1662
Boyle	Canterbury	1626	1690
Huygens	Hague	1629	1695
Barrow	Suffolk	1630	1677
Spinosa	Amsterdam	1633	1677
Cassini (the Elder)	Piedmont	1635	1712
Hook	Isle of Wight	1635	1702
Gregory (James)	Aberdeen	1639	1675
Picard (Abbé)	France	——	1683
Newton (Sir Isâac)	Woolstrope	1642	1727
Roëmer	Jutland	1644	1710
Leibnitz	Leipsic	1646	1716
Flamsteed	Denby, in Derbyshire	1646	1719
Bernoulli (James)	Basil	1654	1705
Halley	London	1656	1742
D' Hopital (Marquis)	Auvergne	1661	1704
Bernoulli (John)	Basil	1667	1747
Boerhaave	Leyden	1668	1738
Cassini (the Younger)	Paris	1672	1756
Richer	France	(*fl.* 1672)	
Bradley	Sherbourne	1692	1762

III.—INTELLECTUAL PHILOSOPHERS,

Who flourished from A. D. 1450 *to* 1700.

NAMES.	COUNTRY.	BORN.	DIED.
Erasmus	Rotterdam	1466	1536
Budæus	Paris	1467	1540
Machiavel	Florence	1469	1550
More (Sir Thomas)	London	1480	1535
Luther	Saxony	1483	1546
Scaliger (Julius Cæsar)	Verona	1484	1558
Ludovicus Vives	Valencia	1492	1536
Melancthon	Bretten	1497	1560
Bodinus	Angers		1585
Ramus	Picardy	1515	1572
Montaigne	Perigord	1533	1592
Scaliger (Jos. Just.)	Agen	1540	1609
Lipsius	Louvain	1547	1606
Thuanus (De Thou.)		1553	1617
Casaubon	Geneva	1559	1614
Bacon (Lord Chancellor)	London	1561	1626
Bruno	Nola, in Naples		1600
Campanella	Calabria	1568	1639
Usher (Archbishop)	Dublin	1580	1657
Grotius	Delft, in Holland	1583	1645
Hobbes	Malmesbury	1588	1679
Gassendi	Provence	1592	1655
Des Cartes	Touraine	1598	1650
Arnauld	Paris	1612	1694
More (Dr. Henry)	Grantham	1614	1687
Cudworth	Somersetshire	1617	1688
Barrow	Suffolk	1630	1677
Puffendorf	Saxony	1630	1694
Huetius	Avranche	1630	1721
Locke	Wrington, near Bristol	1632	1704
Spinosa	Amsterdam	1633	1677
Malebranche	Paris	1638	1715
Leibnitz	Leipsic	1646	1716
Bayle	Foix	1647	1706
Fontenelle	Rouen	1657	1756
Clarke (Dr. Samuel)	Norwich	1675	1729
Berkeley (Bishop)	Thomastown	1684	1753
Montesquieu	Bourdeaux	1689	1755

CHAPTER II.

THE PROGRESS OF THE ABSTRACT SCIENCES.

SECTION I.

ON THE PRINCIPAL MATHEMATICIANS OF THE SIXTEENTH CENTURY.

245. THE history of mathematical science has been sketched, both in its earliest period and its intermediate stages: we now proceed to view it in its full vigour and maturity of growth. The retrospect of the scientific history of the middle ages, it will be remembered, terminated with two illustrious individuals, *Purbach* and *Regiomontanus*, the latter of whom died towards the close of the fifteenth century. But the impulse of his genius was felt long after his death, and its effects were quickly apparent in the rapid improvement of those sciences, to the cultivation of which his distinguished talents had been devoted. Among those who seem to have been stimulated by his example, and encouraged by his brilliant success, was WERNER, who is stated to have been "the first among the moderns acquainted with the method of geometrical analysis." In an earlier part of this elementary history, some account was given of the invention of this beautiful method of demonstration. (§ 72.) It seems, however, to have been long forgotten, if not wholly

lost in subsequent ages: nor was any book known to exist which contained a development of this system, by the help of which the ancient mathematicians were enabled to demonstrate so many simple and elegant propositions. "*Euclid's Data*" was the only work then discovered, bearing, however remotely, on the subject. With this slender assistance, Werner re-discovered the "Method of Analysis," and applied it to the solution of some of the most difficult problems. His mathematical works are now little known, having been long since superseded by others of far greater value.

246. CARDAN and TARTAGLIA were contemporary algebraists, whose united labours contributed in no ordinary degree to the advancement of that science. The former was born at Milan, A.D. 1501; the latter at Brescia, a few years after. Cardan is best known to posterity on account of the celebrated rule for solving equations of the third order, which still bears his name; but to Tartaglia seems rather to have belonged the honour of the invention. A hateful rivalry subsisted between these two distinguished mathematicians, which only terminated with their death, in consequence of Cardan having taken to himself the merit of this scientific discovery, which Tartaglia asserted to have been communicated to him in confidence, and under a promise of secrecy. Cardan, on the contrary, affirmed, that though the formula was communicated to him by Tartaglia, the method of demonstrating it was discovered jointly by himself and his pupil *Ferrari*, the latter of whom carried the process farther, by solving equations of

the fourth order.* However the question may be determined with respect to the inventor of the celebrated rule ascribed to Cardan, the effect was manifest in the rapid improvement of the science of analysis. Some other algebraic discoveries of Cardan materially contributed to this result. He reduced to a more regular system the mode of notation in algebraic quantities, with reference to letters, signs, and co-efficients; improvements which, though they may appear of little importance in the present advanced state of the science, were, when first discovered, of great utility and value. Tartaglia made also some useful discoveries in geometry, the results of which will be found in his treatise on "Numbers and Measures;" in which he first developed the method of determining the area of a triangle, by its three sides alone, without the aid of a perpendicular.

247. Several mathematicians of inferior name, flourished about the same period, in different parts of Europe, whom it will be sufficient cursorily to notice. These were, *Commandine,* who translated and commented on Euclid's Elements, the physical works of Archimedes, Aristarchus, Hero, Ptolemy, Pappus, and the Arabian astronomers; — *Nonius* of Lisbon, the inventor of a useful mathematical instrument employed in mensuration, which still bears his name; — *Stiphelius,* a German alge-

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* Further particulars respecting this controversy between Cardan and Tartaglia, will be found in Montucla's and Bossut's History of Mathematics; and in Playfair's Dissert. apud Encyc. Britt. N. Supp. pp. 13, 14.

braist, who suggested some improvements in the use of *negative* and *positive* quantities;—*Recorde*, an English analyst; and *Pelitarius*, a French mathematician, who directed their chief attention to algebraic equations;—and especially *Bombelli*, of Bologna, who pushed forwards the discoveries of Cardan, by resolving what appeared to that distinguished algebraist to be an *irreducible* case.

248. About the middle of the sixteenth century, we meet with a mathematician who was justly esteemed the "greatest geometer of his age." This was MAUROLYCUS, born at Messina, in Sicily, A.D. 1494; a man profoundly skilled in all the departments of mathematical science, but who chiefly excelled in that of geometry. "His treatise *on Conic Sections*," says Professor Playfair, "is highly esteemed. All his writings indicate a man of clear conception and strong understanding, though he is taxed with having dealt in astrological prediction." Maurolycus applied himself to a branch of analytical calculation at that time almost unknown. This was the summation of several series of numbers, such as those of natural numbers, of their squares, and of triangular numbers. On this subject he framed theorems remarkable for subtilty of invention and simplicity of result.* Besides his original works, he bestowed great labour on the remains of the ancient mathematicians; particularly the "Conics" of Apollonius, which he endeavoured to restore and illustrate by valuable critical and scientific commentaries.

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* Playfair's Dissert. p. 5; Bossut's Hist. of Mathem. p. 209.

249. The close of the sixteenth century forms a splendid æra in the history of mathematical science; but the greater part of the geometricians of that age pursued these studies, not so much for their own sake, as on account of their inseparable connexion with astronomy, or some other department of natural philosophy. They may, therefore, be introduced with more propriety into those sections which will include a review of the history of physics at this period. Copernicus, Kepler, and Galileo, could not have made their splendid scientific discoveries without a high degree of mathematical science; though they owe their chief celebrity to their astronomical researches and discoveries. But one distinguished individual must be mentioned in this place, who was chiefly, if not exclusively, attached to the study of the abstract sciences, and to whom the science of algebra owes peculiar obligations. VIETA was a celebrated French algebraist, who flourished about A.D. 1580; and whom Professor Playfair has characterized as "an illustrious man, and excellent mathematician, remarkable both for industry and invention." To him is attributed the very important invention of "the application of letters, in algebraic formula, to *known* as well as to *unknown* quantities." He gave also some rules for resolving cubic and biquadratic equations; discovered the relation between the different sorts of equations and the coefficients of their terms; and, above all, was eminently successful in the application of algebraic

analysis to the solution of geometrical problems; thus pointing out more clearly the connexion between the two kindred sciences. To these valuable discoveries may be added his improvements in trigonometry, and his treatise on "Angular Sections." The general result of his labours in mathematical science was, that, by the improvements which he suggested, (and of which it is impossible here to give an adequate idea,) the language of algebra then first acquired a regularity which it never before possessed, and became capable of expressing general truths, attaining by this means an extension which has rendered it one of the most efficient instruments of investigation. His works were originally published about A.D. 1600.

250. Before this rapid sketch of the mathematical history of the sixteenth century is concluded, we must not omit to mention two individuals, who were celebrated in their day, though eclipsed by the brightness of surrounding luminaries. *Fernel*, physician to Henry II., wrote several treatises on pure mathematics and on astronomy, which were highly scientific; but his mathematical fame chiefly rests on his having been the first, among the moderns, who attempted the exact measurement of the earth. Though the means employed for this purpose were imperfect, the result to which he attained was very near to the truth. The other was *Albert Girard*, a Flemish mathematician, who, availing himself of the then recent discoveries of Vieta, brought them to bear successfully on other parts of algebraic science, and proved their extensive and almost

universal application. Playfair, after having enumerated the series of scientific inventions attributed to Girard, concludes with this high encomium: "This is the greatest list of discoveries which the history of any algebraist could yet furnish."

SECTION II.

THE HISTORY OF MATHEMATICS CONTINUED,

From A.D. 1600 *to* 1650.

251. THE commencement of the seventeenth century is rendered memorable in the history of the abstract sciences, by its being the æra of a noble and most useful discovery, that of *logarithms*; a discovery, which, by its abridgment of numerical calculations, has rendered the most important service to science in general, but especially to that of astronomy. The labour of effecting the necessary calculations to measure the distances of the heavenly bodies, and other complicated and lengthened investigations, by the ordinary process of arithmetic, had become exceedingly burdensome to the mathematicians and astronomers of Europe. But the discovery of logarithms simplified the process, and rendered it comparatively easy. Baron NAPIER, of Marchiston, in Scotland, was the undisputed inventor of this improved method of calculation, which was first announced to the public in a work, published at Edinburgh, A.D. 1614, entitled, "*Logarithmorum Canonis Descriptio.*" Of this admirable system, a detailed

account cannot be given in this elementary work: suffice it to state, that by the construction of tables, in which two series of numbers are arranged, one in arithmetical, and the other in geometrical progression, corresponding to each other, results were obtained, with great facility and in the most summary manner, by addition or subtraction alone, which had previously required tedious and almost interminable processes of multiplication or division. The ingenious inventor did not live to complete his undertaking, though he proceeded far towards its accomplishment. The *logarithmic* tables begun by him, were improved, finished, and published by his friend and coadjutor *Henry Briggs,* then professor of mathematics in Gresham College. Further improvements were subsequently suggested, in a more advanced period of this century, by *Gelibrand, Gunther,* and *Hadrian Vlacq,* (all of whom were either pupils or personal friends of Briggs,) and by Justus Byrge, a German mathematician of no ordinary attainments.

252. While Napier was pursuing a new track in scientific philosophy, HARRIOTT, an English algebraist and astronomer, was no less diligently employed in advancing his favourite sciences. Following up the suggestions of Vieta and Girard, he arrived at important results which they had not anticipated, and discovered truths to which they had only approximated. The particulars of his researches and improvements in mathematical science are contained in his work entitled "Artis Analyticæ Praxis," published after his death. To him is attributed that important improvement in algebra, which consists "in transposing the terms and changing the signs of equations, so as to arrange them on one side;" a method which has greatly tended to simplify algebraic solutions. Another valuable improvement suggested by Harriott, consisted in the discovery of a method of ascertaining the nature of equations in general by successive multiplications of those of the first order.

253. The celebrated DES CARTES occurs next in order among the mathematicians of this age. We shall have occasion repeatedly to refer to this distinguished philosopher, in connexion with almost every department of physical and moral science; for, after every abatement is made on account of his love of speculation, and his tendency to theorize, rather than calmy to investigate truth, it must be confessed, that few, either in ancient or modern times, have approached so near to the character of an universal genius. At present we have only to do with his mathematical discoveries, which, it will be evident from the following summary, were by no means inconsiderable. In *algebra*, an improvement was made by Des Cartes, which, in the opinion of Playfair, forms a most important epoch in the history of mathematical science; namely, "the application of the algebraic analysis to define the nature and investigate the properties of curve lines, and consequently to represent the notion of variable quantity." To this may be added his more correct notation of algebraic quantities by means of exponents, and a more complete development than

had occurred to Vieta of the relation between geometry and algebra. In *geometry*, this eminent mathematician rendered most valuable service by discovering the means of determining the relations and proportions of different species of curve lines; by drawing tangents and perpendiculars to geometrical curves, and by describing accurately their course of inflexion in any given case. By these abstruse investigations, he prepared the way for future mathematicians, and took an important step towards the discovery of the "Analysis of Infinites," which constitutes the chief glory of modern times.

254. CAVALLERI, who flourished at the same time with Des Cartes, was equal, if not superior, to his illustrious contemporary in mathematical science. He was born at Milan, A. D. 1598, and published his celebrated work on the "Geometry of Indivisibles," in 1635. This great mathematician was a disciple of Galileo, and had associated with Kepler; from both of whom, it is probable, he derived much valuable assistance in the preparation of this highly scientific work. It is divided into seven books, in six of which his new theory is applied to the quadrature of curves, and the cubation of solids; and in the last, the same theorems are demonstrated without the aid of his *method of indivisibles*. To comprehend more clearly the value and importance of this discovery, it will be requisite to call to mind what was stated in a former section of this work, respecting the "method of exhaustions," as far as it was known to the ancient geometricians; (§ 76;)

the object of which was "to determine the lengths and areas of curves, and the contents of solids contained in them." That method was extremely limited in its application, and the demonstrations to which it led could only be attained by tedious and complicated operations. It remained for Cavalleri to devise a more compendious method of effectuating these objects by a principle of universal application. Instead of the circuitous route, by which Archimedes and other ancient mathematicians were led to the accurate measurement of superficial and solid bodies contained in curves, Cavalleri proceeded by a method of analysis of his own invention, *most directly* to the attainment of his object. To this he most properly gave the name of the "*method of indivisibles*." In consequence of this happy and most important discovery, many propositions were demonstrated with the utmost facility, which had baffled all preceding geometricians, and not a few new theorems were invented of singular beauty and elegance.

255. About the same time, a comparatively novel object of research engaged the attention of mathematicians, especially those of the French school. This related to the nature, properties and proportions of that particular species of curves, denominated *cycloids*. This kind of curve was alluded to in the review of ancient mathematics; but little advance seems to have been made towards the development of this curious division of the science, till the commencement of the seventeenth century; and even then, it is difficult to determine by whom the solution was first made. Galileo had in vain

employed his vigorous and penetrating mind in this investigation. Cavalleri, aided as he was by his "Method of Indivisibles," which furnished him with the true key to its solution, yet failed to discover it. The honour of the invention belongs either to *Toricelli,* one of the pupils of Galileo, or to *Roberval,* a French mathematician of high repute. Without presuming to determine a question so fiercely contested by the partisans of each, it may be affirmed, that, by whomsoever discovered, the invention of the "quadration of the cycloid" forms an interesting æra in the history of mathematics.

256. One of the geometricians of the French school has been mentioned incidentally. But it would be an act of injustice to that age and country not to allude more distinctly, both to the mathematical investigations of that individual, and of those several other of his illustrious contemporaries and countrymen, particularly Fermat and Pascal, all of whom may justly be classed with mathematicians of the first order.

FERMAT was born at Toulouse, A. D. 1590, and originally intended to practise in the law, but his genius directing him to the study of the mathematics, he soon relinquished the legal profession, and gave himself up to scientific pursuits. He excelled both as a geometrician and an algebraist. In the former, he may be considered as on the very verge of having discovered the method of *fluxions;* since his investigation of infinitely small quantities, for the purpose of determining the *maxima* and *minima* of geometrical figures, led him to the confines of that important invention, which characterises and ennobles the geometry of modern times. In algebra, Fermat was led to many useful improvements, by his diligent analysis of prime and figurate numbers, and by his intimate acquaintance with the works of Diophantus and the Arabian mathematicians. His original treatises and commentaries on the ancients were collected after his death, in two volumes folio, and are lasting memorials of his science and industry.

257. **Roberval** was the great rival in mathematical science both of Cavalleri and Descartes, of whose well-earned celebrity he was extremely jealous, and with both of whom he maintained many angry controversies. His attention, like that of almost all the geometricians of that period, was directed chiefly to the means of ascertaining the area of curves of different kinds; particularly the quadrature of parabolas and the nature of cycloids. In this abstruse and difficult department of pure mathematics, he proceeded a few steps beyond Cavalleri, since he arrived at the same results by a yet easier process than the *method of indivisibles*. His asperity and vanity are, however, great blemishes in his literary character, for which even his high scientific attainments can scarcely be deemed an adequate compensation.

258. The profound and excellent **Pascal**, whose intellectual powers, and, above all, whose ardent piety shed a lustre on his science and learning, proved, by his inventions in mathematics, that his mighty genius was capable of grasping almost any subject, however abstract and difficult, to which

it could be directed. He opened a new path in analysis, by his well-known *arithmetical triangle,* and in geometry pursued, with brilliant success, the investigation of the cycloid. "Geometricians," says M. Bossut, "regret that he did not dedicate the whole course of his short life to the mathematics; but then we should have lost those celebrated *Provincial Letters,* and those profound *Thoughts,* which are perhaps the master-pieces of French eloquence." —*Hist. of Math.* p. 239.

SECTION III.

HISTORY OF MATHEMATICS CONTINUED.

From A. D. 1650 *to* 1700.

259. HITHERTO we have seen, that scientific men were comparatively insulated, except as far as they were mutually attracted by community of taste and pursuits. In some instances their jealousies kept them from freely imparting the discoveries they had made in art or science to each other. But about the middle of the seventeenth century a better system was adopted. A kind of literary republic was formed throughout Europe, by means of "*Philosophical Societies,*" and "*Academies of Science,*" which were then established in several of its principal cities. To those scientific institutions, all who possessed the requisite qualifications were freely admitted, to whatever country they might belong. Among many other valuable effects produced by

these literary establishments, it soon became apparent, that they stimulated genius, caused knowledge of every kind to circulate more freely, and afforded facilities to the improvement of the arts and sciences, which private individuals could not possess. It is not possible to estimate in how great a degree the vigorous growth of mathematical and physical science, which marked the close of the seventeenth century, is attributable to these important associations.

The first, in the order of time, was the "*Academia del Cimento*," founded at Florence, A. D. 1651. The next was the "*Royal Society*," of London; which, though it had existed as a private literary association at Oxford, during the Commonwealth, was not incorporated by royal charter till A. D. 1662. The "*Academy of Sciences*," at Paris, quickly followed, having been founded A. D. 1666. To these succeeded similar institutions at Berlin, Leipsic, Bologna, St. Petersburgh, and other European cities.

260. Most of the scientific philosophers to whom we shall have occasion to advert, who flourished after this period, were members of one or more of these philosophical institutions. At present, those alone will be selected who contributed to the advancement of mathematical science during the latter half of the seventeenth century.

(1.) WALLIS was one of the earliest and most distinguished members of the Royal Society of London. Like the rest of the mathematicians of that age, he directed his attention chiefly to the doctrine of Infinites, which he investigated both by algebraic and geometrical processes. The result of his long-continued and unwearied researches in this branch of the mathematics, appeared in his celebrated work, entitled "The Arithmetic of Infinites;" a work in itself of great importance, but rendered still more valuable by its having proved the occasion of the most important discovery of modern times.

(2.) HUYGENS chiefly belongs to the class of practical and experimental philosophers; but as a successful fellow-labourer in the mathematical department with Fermat, Wallis, Pascal, and others of his illustrious contemporaries, he must also be included in the list of geometricians of the first order. "One of the greatest discoveries made in modern geometry," writes M. Bossut, "was the theory of *evolutes*, invented by Huygens, and developed by him in his work entitled, 'Horologium Oscillatorium.' The chief object of this invention was to aid in the *rectification* of curves, and especially cycloids; that is, to determine their exact quantity in right lines. The uses," it is added, "of this theory, in all parts of the mathematics, are without number[*]." The same object was pursued by means of infinite series, and similar results were obtained, by two eminent English mathematicians, who flourished at that period, namely, *Brouncker* and *Mercator;* each of whom, separately and simultaneously, made the same discovery respecting the areas of hyperbolas and other curves; and who may be considered as proceeding, by almost imperceptible, but certain steps, towards the more important invention of the new analysis.

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[*] Bossut, p. 240.

(3.) BARROW, who is proved by his works to have been at once a profound theologian, an acute reasoner, and a distinguished mathematician, is chiefly celebrated in this latter department of science, by his invention of the *differential triangle;* which may be considered as another important step taken towards the discovery of fluxions. Its chief utility consisted in enabling the geometrician to draw tangents to curves by a shorter and simpler process than that previously discovered by Fermat; but it fell far short of the "Method of Fluxions," inasmuch as it would apply only to a single case instead of giving a formula of general, or rather universal application.

(4.) JAMES GREGORY was another coadjutor in that great work, which employed, at this period, the investigation of the profoundest mathematicians of Europe. He discovered, by a new process, a method of infinite series, applicable to tangents and secants, which materially assisted in determining the quadrature and rectification of curves.

261. Having cursorily noticed the principal English mathematicians, who flourished at the close of the seventeenth century, (with the exception of our illustrious Newton, whose mathematical discoveries were so splendid that they may justly claim to be separately and distinctly reviewed); it remains to enumerate some of the continental geometricians, of distinguished reputation, who added to the lustre of this splendid æra.

(1.) The Marquis D'Hopital acquired and merited the reputation of a first-rate mathematician, at a period in which it was no easy task to secure so honourable a distinction. His mathematical genius discovered itself in early youth; for it is stated, that, at fifteen years of age, he solved some of the most difficult problems. He was the first of the French school, who published on the analysis of Infinites, then newly discovered by Leibnitz and Newton. His work on this subject, "completely unveiling a science, which had hitherto been but indistinctly and imperfectly developed, excited universal admiration, which was so much the greater on account of the elevated rank of its author, and which still retains its place among the standard treatises on the differential calculus." This great mathematician was employed in preparing a series of tracts on the conic sections, equations, infinite series, and other subjects connected with pure mathematics, when he was arrested by the hand of death, on the second of February, 1704, in the forty-third year of his age.

(2.) James and John Bernoulli,---two brethren by birth, but rivals in literary fame, and, it is painful to add, in the later period of their lives, open enemies to each other,—pursued, with unwearied assiduity, the same series of investigations, though not with equal success. "The progress they made," says M. Bossut, "conjointly or separately in the new analysis, was rapid. A noble emulation, strengthened by the ties of blood, of friendship, and of gratitude, directed their studies for two or three years. Covetous of nothing but knowledge, they were stimulated only by the sublime emulation of penetrating into the labyrinths of science now laid open to their curiosity, and that unhappy rivalship, which borders on envy, did not yet disturb their enjoyments." The concluding portion of their literary career exhibits but too melancholy a reverse of this enchanting scene. An immense number of valuable tracts proceeded, year by year, from the pen of these scientific brethren, both in separate publications and in the philosophical journals of the age, which it would be tedious and useless to enumerate. The more important of them related to the catenary curve, or that formed by a heavy flexible and inextensible cord, fastened at its extremities to two fixed points, (a subject intimately connected with the science of mechanics, though in itself mathematical,)—to the nature and properties of cycloids—to elastic, isochronous, and paracentric curves—and especially to the geometry of infinites. Towards the close of his life, James Bernoulli received the well-merited honour of an appointment to the professorship of mathematics in the University of Basil, the place of his birth, and thus obtained additional facilities for prosecuting his studies in mathematical and physical science.

262. The celebrated LEIBNITZ is last mentioned, not as latest in the order of time, or inferior in scientific attainments, for on both these grounds he may justly take the precedence; but because the principal facts of his literary history (especially in connexion with the abstract sciences) are so interwoven with those of the illustrious Newton, that it seemed most desirable to place them in juxta-position.

This eminent philosopher was born at Leipsic on the 4th of July, 1646. His father having been professor of moral philosophy in the university of that city, he grew up in the atmosphere of learning, and early imbibed a taste for almost every species of literature. Among other branches of science to which his youth was devoted, the mathematics were not forgotten; in which he made so great proficiency, as to maintain a public thesis in the year 1663, on a question of considerable difficulty.—His advancement to academical honours was retarded by his rejection of the principles of Aristotle and the Scholastics, who still retained great influence in the principal universities of Europe; but at length the genius and talents of Leibnitz bore down all opposition, and procured for him the highest literary distinctions. Some of his earlier publications related to questions of jurisprudence and subjects connected with intellectual philosophy, which will be adverted to hereafter. But the investigations of Pascal, Gregory, Huygens, and Wallis, fired his ambition, and prompted him to apply the energies of his powerful mind to those intricate and abstruse subjects, in which they had been so successful. In 1684, he published, in the Leipsic Philosophical Transactions, "A new Method for Maxima and Minima," &c. In 1685, two tracts were published by him on the quadrature of curves; and in almost every succeeding year, numerous proofs were afforded of his high mathematical attainments, either by valuable communications to literary journals, or by separate treatises on the most profound subjects of analysis. But the most remarkable fact connected with the literary history of Leibnitz, relates to the celebrated controversy respecting the originality of his invention of the *differential calculus*, which will form the principal subject of the next section. That a discovery which opened so new and wide a field to modern science, and so greatly enlarged the boundaries of human knowledge, would reflect immortal honour on its inventor, it was not difficult to foresee; and in proportion as this conviction was felt, the partizans on either side felt determined to secure the laurel for the brow of their favourite philosopher. Time has allayed the passions, and subdued the prejudices which this controversy once excited, and furnished the requisite means of forming a more impartial and correct judgment.

SECTION IV.

ON THE MATHEMATICAL DISCOVERIES OF SIR ISAAC NEWTON.

263. IT will not be expected, from the title prefixed to this section, that the writer of these pages proposes to give a detailed account of the prodigious labours and brilliant discoveries of the most renowned of modern geometricians. This would require more space than the assigned limits of the present work would admit, and a much higher degree of science than that to which its author can pretend. Yet, as the age of Newton forms a new and most important æra in the history of mathema-

tical science, it is requisite that an attempt be made in this place to convey some faint conception of the *new geometry*, of which he is justly considered the inventor, and by the aid of which, science has subsequently made such rapid progress. This may be done as a matter of history, without attempting to explain the process by which these valuable results were obtained.

264. In order to understand the true nature of those geometrical discoveries to which we are now alluding, it is necessary to recall to recollection what was stated respecting the discoveries of the most celebrated mathematicians of Greece. When reviewing the history of the abstract sciences in the time of Euclid and Archimedes, it was stated that those celebrated geometricians, by the aid of the "*Method of Exhaustions*," and their investigation of quantities infinitely small, prepared the way for that department of mathematical science, to which the moderns have given the names of "*Differential Calculus*," "*Infinitesimal Analysis*," or "*Fluxions*." (§ 76.) After the lapse of more than two thousand years, the "Method of *Exhaustions*" gave place to that of "*Indivisibles*," invented by Cavalleri; by means of which, the same objects were attained with greater ease and accuracy *analytically*, which the ancient geometers had discovered by *synthetical* reasonings. (§ 254.) Following this track, the great mathematicians of the sixteenth and seventeenth centuries, who have been enumerated, particularly Toricelli, Roberval, Fermat, Pascal, Huygens, Wallis, and Barrow, investigated more closely the doctrine of Infinites, and discovered some important theorems concerning variable or indeterminate quantities, which approximated so near to each other, that no assigned difference could be shewn. Yet there was still wanting some more exact calculus adapted to these researches, which had continued during so many ages to baffle the skill of the most scientific philosophers. Such was the state of the abstract sciences, when Newton and Leibnitz arose, both of whom applied all the force of their mighty genius to the subject. While an undergraduate at Cambridge, Newton met with "Wallis's Arithmetic of Infinites;" and "no book," says Playfair, "could be better fitted to suggest new views of geometry, or call into activity the powers of mathematical invention." The young philosopher quickly discovered where Wallis had failed, and adopting the general principle laid down in his work, discovered a *law*, by which the long agitated problem of the quadrature of the circle, and every other species of curve, might be solved. This led to the invention of his celebrated "binomial theorem," (by steps perfectly easy to such a mind as Newton's, which could only breathe in the atmosphere of science,) and eventually to the method of "*Fluxions.*"

265. The value of this discovery, and the new field it opened to science, rendered the question relative to the history of its invention interesting to all Europe, and gave occasion to a controversy in which many of the men of science of that age took an active part. The question was simply this, whether the honour of this brilliant discovery belonged

to LEIBNITZ or NEWTON. The facts of the case, as abridged from the more full and impartial narrative of Professor Playfair, are the following: "Newton made the important discovery alluded to in early life, but did not publish that discovery till nearly thirty years afterwards. That the method of *fluxions* was known to him as early as A.D. 1665, or 1666, is evident from a letter written by him, about that time, to Oldenberg, one of the secretaries to the Royal Society, in which some results are stated, which could no otherwise have been found, though he does not there explain the process by which they were attained. A yet more decisive testimony is borne on the subject by Dr. Barrow, who affirms that, soon after the above date, Newton, then a young man, placed in his hands a MS. entitled "Analysis per Equationes Infinitas," &c., which he earnestly exhorted his young friend to publish; but which, through an ill-judged modesty, he declined to do: so that, though written as early as 1669, it was not published till 1711. The first work in which any intimation of the method of fluxions was publicly given, and then only as by accident, without a clear development of the process, was his "Principia," published A.D. 1687. The principle of the fluxinary calculus is there announced, but the method itself is not explained. This did not appear till A.D. 1693, when it was appended to the second volume of a new edition of Wallis' Mathematical Works. This is, therefore, the true date of the publication of this new theory by Newton.

266. In the mean time, Leibnitz had developed in some of his writings, published before this latter period, his system of the *differential calculus;* the principles and objects of which are precisely the same, and the results similar to those of fluxions, though the method of notation differs. The earliest intimation given by Leibnitz of this discovery is found in a letter addressed by him to the same Oldenberg, bearing the date of A. D. 1676, which is more than ten years later than the invention of his illustrious contemporary. The conclusion, to which Playfair is led by the preceding facts, differs somewhat from the view still taken of the controversy by many of the continental philosophers, but seems perfectly equitable and just; namely, that of the infinitesimal analysis, Newton was the *first,* and Leibnitz the *second inventor.* For nothing appears to have been communicated by Newton, either to his personal friends or to the world, which could have suggested to Leibnitz a knowledge of the principle on which that analysis was founded, before the public announcement by Leibnitz of the differential calculus: and still less was the geometrical process developed by which it had been obtained. Leibnitz must have known, from the active correspondence then maintained by men of science, that some such discovery had been made, and this knowledge probably excited his curiosity, inflamed his ambition, and stimulated his exertions; causes which, in addition to the progress previously made by Wallis and others, will sufficiently account

for his having been led to a new and independent, though similar, and almost simultaneous discovery.*

267. The new flood of light thus poured on a science, which leads to truth and certainty by means of absolute and infallible demonstrations, was hailed as an event of no ordinary importance. Though some, whose imperfect knowledge prevented them from duly appreciating its value, or whose dread of innovation armed their prejudices against it, or whose jealous disposition could not brook a new and formidable rival, started objections, and affected lightly to esteem this great invention; the principal mathematicians of the age (the venerable Huygens, then in extreme old age, not excepted) most readily and gladly adopted it as the basis of their future researches. Its principal value consisted in its adaption to physical investigations, and, above all, the immense benefit derived from it, in carrying on those astronomical calculations, in which the utmost precision is necessary. The "analysis of infinites" enabled Newton to meet and eventually to remove the principal difficulties, with which former philosophers had long contended unsuccessfully. A great variety of mathematical tracts were written and published by Newton at different periods of his life: indeed, almost the whole of the imperishable productions of his pen partake more or less of this character. Not a few will be found in a scattered form among the annual publications of the "Royal Society," which were greatly enriched by his com-

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* Vide Playfair's Second Dissert. apud Encyc. Britt. N. Supp.

munications. Some were published separately, of which the most important were his "Letters in the Commercium Epistolicum,"* published A.D. 1711; his "Treatise on the Quadrature of the Curve," written in 1666, but not published till 1704; and his book on "The Method of Fluxions and Analysis by Infinite Series," published after his death, in 1736.

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[*] The "Commercium Epistolicum" was the official *Report* of the Royal Society relative to the disputed claims of Newton and Leibnitz; and contained all the communications which had passed between these two great philosophers and their respective friends on the subject of the new analysis, from the beginning of the controversy to the time of its publication. It set the question at rest in England: but a disposition manifested itself among the foreign mathematicians to rob Sir Isaac Newton of his well-earned honours long after this period.

CHAPTER III.

HISTORY OF PHYSICAL SCIENCE CONTINUED.

I. ASTRONOMY.

SECT. I.—ON THE PRINCIPAL ASTRONOMERS OF THE SIXTEENTH CENTURY.

268. THE period which is now to pass in review, forms a most splendid æra in the history of astronomical science. The progress made in this important branch of philosophy was so rapid and great—the new discoveries were so various and astonishing—that, compared with them, all the attainments of preceding ages, from the earliest records of authentic history, vanish into utter insignificance. It will only be possible to glance at some of these discoveries in the order in which they were announced to the world, and to enumerate a few of the distinguished individuals to whose inventive genius they are attributed.

269. COPERNICUS must be first mentioned, as confessedly *the great founder of Modern Astronomy.* He was born at Thorn, in Prussia, A. D. 1472, but did not commence that astronomical career, which has given celebrity to his name, till the beginning of the following century. Originally intended for a physician, he applied himself, in early youth, to the

study of medicine, but afterwards took orders in the Church of Rome, that he might pursue, with greater advantage, his philosophical researches. His literary ardour first manifested itself in the department of mathematics, by which he was naturally led to astronomy, as a science which opens the widest field to geometrical investigation. He soon perceived the deficiency and fallacy of all the theories of the ancients respecting the planetary system, except that which Pythagoras is said to have darkly conjectured many ages before, though he was unable to demonstrate its truth. (§ 87.)

It appears, from the statement of Copernicus himself, that he first began to entertain doubts of the truth of the *Ptolemaic* system, about A. D. 1507; and that these doubts were occasioned by the difficulty he found in reconciling that system with the simplicity and uniformity of the laws of nature. It soon appeared, that by transferring the *sun* to the centre of the planetary system, instead of the *earth;* by giving to the earth a twofold motion, one on its own axis, and another in a prescribed path or orbit round the sun; and by applying the same theory to the rest of the planets, many of his difficulties vanished, and the celestial phænomena, the solution of which before seemed impracticable, were explained with a facility at which he was perfectly astonished. The simple fact that led the mind of Copernicus to this discovery, was one of those familiar and everyday scenes, which must have been observed a thousand times both by the peasant and the philosopher; namely, the optical illusion which takes place when a spectator imagines the objects on the banks of a river to be moving in an opposite direction to that in which he is himself proceeding. The conjecture was natural, that the same illusion may happen with respect to the sun's apparent motion, and those of the heavenly bodies. In his reasonings on the subject, there are some sound and solid arguments indicative of true science; but others were errors into which he was betrayed by his remaining attachment to ancient systems. Well knowing the dread of innovations, whether in philosophy or religion, which had ever characterized the Church to which he belonged, he did not venture to announce publicly either his rejection of the ancient, or his discovery of a new theory, till nearly the close of life. It is more than probable, that if he had earlier developed a scheme so completely at variance with the orthodox faith, he would have fallen a sacrifice to the ignorance and bigotry of the times, and, like one of his successors, languished away the remnant of his existence in the prisons of the Inquisition. He was, however, induced in advanced life, by the persuasions of Cardinal Schoenberg, to publish a work, written with great caution, and containing many apologies for the novelty of some of its statements, in which the true doctrine of the solar system was developed. This book, which originally was entitled "De Revolutionibus Cœlestibus," but afterwards more appropriately styled "*Astronomia Instaurata*," was published A. D. 1543, and dedicated to the Roman Pontiff; nor is it a little remarkable, that this great astronomer died on the very day in which the first complete printed copy of this work was put into his hands.

270. The new theory of Copernicus attracted little attention, when first promulgated. "It lay fermenting in secret," says Playfair, "with other new discoveries, for more than fifty years, till by the exertions of Galileo, it was kindled into so bright a flame, as to consume the philosophy of Aristotle, to alarm the hierarchy of Rome, and to threaten the existence of every opinion not founded on experience and observation." During this interval, which may be regarded as a kind of intellectual twilight, TYCHO BRAHE, the celebrated Danish astronomer, arose and flourished; a man of genius, of science, of unwearied industry; but who, unhappily, suffered himself to be so fettered by early prejudices, or so intimidated by the fear of man, as not to dare to follow up his own convictions, or pursue the course of his own discoveries. He was the inventor of a system, which bears his name, and which takes a middle course between the *Ptolemaic* and the *Copernican;* for while it agrees with the former, in supposing the earth to be the immoveable centre of the whole planetary sphere; it represented first the *moon* as revolving round it; and next the *sun,* carrying with him in his revolution, the five primary planets as his satellites. Had this theory been developed before the publication of the "Astronomia Instaurata" of Copernicus, it might have been hailed as one, and that not an unimportant step in advance; but appearing when it did, it must

rather be accounted a retrograde movement. There is, however, reason to believe, that Tycho Brahe was far from being satisfied with this theory, though he attempted to reconcile with it the actual phænomena of the celestial motions. Nor can we wonder that, rapidly progressive as mathematical science then was, this system should have obtained few converts and been soon forgotten, except as a matter of history.

271. The services rendered by Tycho Brahe to the sublime science of astronomy, were however great and highly important, for (1.) he prevailed upon the King of Denmark to establish an observatory at Uranïberg, and to furnish it with the most accurate instruments that could be procured from any part of Europe. Aided by these advantages, he not only made an immense number of astronomical observations himself, but collected around him a band of scientific men ardently devoted to the same pursuits, and founded a school of astronomy, from which not a few eminent astronomers proceeded to illumine the world.

(2.) Many years had now elapsed, since the attempt of Hipparchus and Ptolemy to number the stars, and far superior instruments for the purpose were now constructed (§. 86. 89.) The Danish astronomer determined, therefore, to renew the attempt, and, after a long series of minute observations and accurate measurements, produced a catalogue of the fixed stars, amounting to 777, whose situation in the heavens was determined with as much precision as the state of science would then permit, though far less accurately than in some of the catalogues subsequently made. The greater correctness of Tycho Brahe arose not merely from the superiority of his instruments, but from his employing the planet Venus, instead of the moon, as the basis and rule of his calculation for determining the longitude of the fixed stars.

(3.) Another object, to which the astronomical researches of Tycho Brahe was directed, and in which he was materially aided by his mathematical science, related to the irregularities which had been long observed in the lunar motions, the true cause of which was as yet unknown. This astronomer laboured most assiduously to ascertain the degree of these irregularities, the periods when they occurred, and their influence in causing a difference between lunar and solar time, in all which researches he was eminently successful.

(4.) A series of useful calculations were made by him on the subject of atmospherical refraction, the object of which was to determine, by an equatorial instrument of his own invention, the angle at which that refraction becomes visible, and the degree of refrangibility at different altitudes.

(5.) No inconsiderable degree of light was thrown by this indefatigable astronomer on the theory of comets; one of which, (that of 1570,) he observed most carefully and minutely as long as it remained visible in our hemisphere; and, from these observations, he inferred that, like the planets, they are solid opaque bodies, revolving round the sun, though in extremely eccentric orbits. The above are among the most important astronomical investigations of this practical philosopher, to which many others of subordinate interest, but yet which indicate unwearied diligence of research, might have been added.

272. WILLIAM IV. the Landgrave of Hesse Cassel, and POPE GREGORY XIII. contributed essentially to the advancement of astronomical science, towards the close of the sixteenth century: the former by his personal observations as a practical astronomer; the latter by his efforts to procure a reformation of the calendar. In surveying the records of past ages, it is grateful to fix the eye for a moment on a prince, who, instead of being carried away by the lust of ambition, and spreading abroad the miseries and calamities of war, devoted his leisure hours to philosophical pursuits. Such was the venerable Landgrave of Hesse Cassel, who built an observatory in the capital of his principality; made numerous observations on the position of the fixed stars and constellations; and called in the aid of science to determine the solstitial altitudes, with many other astronomical phænomena.

The pontificate of Gregory was rendered illustrious by the adoption of that new arrangement of the calendar, which still bears his name. The errors of the former arrangement had been long felt; and repeated, though ineffectual, attempts made to correct them. But Gregory took the most effectual method to accomplish this object, by inviting all the astronomers of Europe to give their utmost attention to the investigation, and offering a reward to such as should suggest the best scheme for the more accurate measurement of time. Numerous plans were suggested, but among them all, that of *Aloysius Lillius*, an astronomer of Verona, obtained the preference, and was accordingly adopted. In the year 1582, this reformation was carried into effect, and gradually superseded the use of the Julian calendar.

273. We pass on to notice an astronomer who was the glory of his age and country, and whose name can never be forgotten so long as any records remain of physical science. This was KEPLER, who has been designated "the creator of true physical astronomy." He was born at Wirtemberg, A. D. 1571, and in early life distinguished himself both by his physical researches and invaluable writings. He is chiefly celebrated as the philosopher, who first discovered the *laws* of the planetary motions; the theory of which was partly known to Copernicus and Tycho Brahe, but the development and demonstration of which is altogether his own. The steps by which Kepler was led to this important discovery, the train of reasoning pursued in demonstrating the truth of these general laws, and the methods of calculation adopted for this purpose, cannot be detailed here. They will be found at length in his celebrated work, entitled "*Astronomia Nova,*" published A. D. 1609; and in a more abridged form in most of the modern treatises on astronomy. Suffice it to say, that they resulted in what are technically termed the *first and second laws of Kepler;* the former of which relates to the proportion between the areas and times of planetary revolutions,

and the latter determines their mean distances. The general LAW, in which both the preceding were combined, is thus perspicuously stated by the late Professor Playfair; "that in any two planets, the squares of the times of the revolutions are as the cubes of their mean distances from the sun." "This beautiful and simple law," adds the same excellent writer, "had a value beyond what Kepler could possibly conceive. Yet a sort of scientific instinct instructed him in its great importance; for he has marked the day and year, when it became known to him; it was on the 8th of May, 1618; and perhaps philosophers will agree that there are few days in the scientific history of the world which deserve so well to be remembered."*

274. But important as were these discoveries, they were not the only contributions of this great philosopher to his favourite science. Having demonstrated by physical experiments the *inertia* of matter, he applied it as a general principle, by which to explain the phænomena of the planetary revolutions. Kepler was the first who employed the above term, to denote the tendency of bodies when in motion, or at rest, to continue in the same state; and who proved that all motion is naturally rectilineal; whence he inferred, that if a body moved in a curve, (as is the case with all the planetary bodies,) it must be *drawn out* of its natural track by some external cause. The important use made of this discovery by the illustrious Newton will

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* Playfair's Second Diss. pp. 87, 88.

hereafter appear. The objects to which the researches of this indefatigable astronomer were directed, during a life wholly devoted to practical science, were so varied and almost innumerable, that many must, of necessity, be passed over in this rapid sketch. The more important related to the calculation of eclipses; the measurement of parallaxes, both diurnal and annual; the determination of the planes of the planetary orbits, and consequently of their nodes; their greater or less degree of eccentricity, and their angular motions or irregularities of movement at different periods of their revolution. To convey some conception of the prodigious labour bestowed by this great astronomer on some of his minutest calculations, and for the purpose of proving to the youthful reader of these pages, that "there is no royal road to astronomy," the following extract from Playfair's Dissertation is subjoined:—"The industry and patience of Kepler, in this investigation, (alluding to his observations upon the orbit of Mars,) were not less remarkable than his ingenuity and invention. Logarithms were not yet known, so that arithmetical computation, when pushed to great accuracy, was carried on at a vast expense of time and labour. In the calculation of *every opposition of Mars*, the work filled ten folio pages, and Kepler repeated each calculation ten times, so that the whole work for each extended to one hundred such pages: seven oppositions thus calculated produced a large folio volume. In these calculations, the introduction of hypothesis was unavoidable, and Kepler's candour in rejecting them, whenever they appeared erroneous, without any other regret than for the time which they cost him, cannot be sufficiently admired. He began with hypothesis, and ended with rejecting every thing hypothetical. In this great astronomer, we find genius, industry, and candour, all uniting together as instruments of investigation."*

SECT. II.

HISTORY OF ASTRONOMY CONTINUED,

From A. D. 1600 *to* 1650.

275. THAT the beginning of the seventeenth century will be ever memorable in the annals of scientific history, all will readily admit, who remember, that then GALILEO flourished; that the telescope was then invented; and that, in consequence of this happy invention, a new and almost boundless field of research was opened to astronomers. GALILEO was born at Florence, about A. D. 1564, became mathematical professor in the University of Pisa in 1589, and in that of Padua in 1592. About the year 1609, the intelligence first reached him, that a Dutch optician, named Metius, had contrived a method of fixing two glasses in such a position as greatly to magnify objects seen through them. This hint was sufficient to fire the genius, and arouse the energies of Galileo, who commenced a series of experiments on lenses variously combined, till he

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* Playfair's Second Diss. p. 87.

happily discovered that most important of all astronomical instruments—the *telescope*.* Aided by his own inventive genius alone, he constructed a telescope formed of two lenses, (that nearest to the object, convex; and that placed near the eye, concave,) which possessed a power of magnifying thirty-two times beyond that of the naked eye. Having first tried the effect of this instrument on terrestrial objects, he next applied it to the heavens; and was amply rewarded by a series of the most astonishing discoveries. A brief outline of these, is all that can now be attempted; but their general result, in spite of all the bigotry of superstition, and all the terrors of the Inquisition, was, the utter subversion of the *Ptolemaic*, and the absolute demonstration of the *Copernican* system.

276. (1.) The moon was first subjected to attentive observation, on whose surface were perceived numerous inequalities, which led Galileo to the conclusion that this secondary planet resembles the earth, being divided into continents and oceans, and interspersed with mountains, lakes, and rivers. The accurate delineation of the map of the moon, which he was thus enabled to make, greatly assisted in determining the time of its diurnal revolution, and in explaining many other curious phænomena respecting it.

(2.) The fixed stars next engaged his attention, and the delight of this philosopher may be more easily conceived than described, at finding that multitudes of these distant luminaries were then, for the first time, brought within the sphere of human vision, on which the eye of man had never before rested, and which were not previously known to exist; yet even *he* had no conception of the far greater multitudes to be discovered by more powerful instruments, and affording the most overwhelming conception of the magnitude, the immensity of the universe.

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* Some farther particulars respecting the history of this invention, and its successive stages of improvement, will be found in a subsequent section, under the head of *optics*. (§ 328.)

(3.) The phases of Venus, resembling those exhibited by the moon, had been conjectured by Copernicus as highly probable phænomena, but were fully demonstrated by the telescopic observations of Galileo.

(4.) Some of the satellites of Jupiter were next discovered by this illustrious astronomer. When three of these were first seen by him near the body of the primary planet, he took them for fixed stars; but perceiving, by oft-repeated and long-continued observations, that they always accompanied Jupiter in his revolution, and constantly changed their places with reference to each other, as well as in relation to their primary, he concluded that they were really moons. This conclusion received further confirmation and proof by observing their eclipses, their periods of conjunctions and opposition, their periodical revolutions, and many similar phænomena.

(5.) When contemplating the planet Saturn, with the aid of his newly invented telescope, Galileo was struck with the singularity of its appearance. It seemed to him like three luminous globes, the larger in the middle, and a smaller on either side. His observations were continued, till he found the two lesser globes disappear, and the planet looked single and circular, like the rest of the planetary bodies. This was the only explanation this philosopher could then give of the well-known phænomena of Saturn's ring, the complete discovery of which was reserved for future astronomers.

(6.) Galileo discovered with his telescope some dark spots on the sun's disk, by the attentive observation of which he was enabled not only to prove that that luminary revolves on its axis, but with some degree of accuracy to determine the time of his revolution.

(7.) Above all, to Galileo we are indebted for the complete demonstration of the true solar system; since he fully proved, by a multitude of observations on the orbits and revolutions of the planets, their common relation to the sun; and thus established, on an immoveable basis, the true theory of the heavens.

277. This brilliant assemblage of astronomical discoveries was first made public about A.D. 1613, in "Dialogues on the System of the World," which contained a full exposition of the evidence of the earth's motion, and placed the errors of the old in striking contrast with the discoveries of the new philosophy. This work was written with singular perspicuity of reasoning, and true eloquence. It was read by scientific men with an enthusiasm of delight little inferior to that which its illustrious author had experienced in the discoveries themselves.

But the state of society was not as yet sufficiently advanced to admit of the unrestricted investigation of truth: and a very short time elapsed from the publication of the work containing these important developments, before its unfortunate author found to his cost the truth of this remark.

The history of the persecutions endured by this great philosopher through a long series of years, on account of his defence and practical demonstration of the Copernican system, forms a melancholy and most disgraceful page in the annals of science. The Jesuits, the prelates and cardinals of the Church of Rome, with the pontiff at their head, alarmed at the progress which this new species of heresy was making, cited Galileo before the Court of Inquisition, and there bound him by solemn oath to abjure his errors, and subscribe a written avowal of his belief in the Ptolemaic system, which he had proved to be false; at the same time pledging himself never to publish any thing in future contrary to the doctrine of the holy Roman church on this subject.* To this, after a tedious imprisonment, he reluctantly assented; but soon after, having obtained his liberty, committed a yet heavier offence by the publication of a third dialogue, in which he ventured not only to ridicule the advocates of the Ptolemaic philosophy, (not sparing even Aristotle himself,) but also adduced additional facts in proof of the true theory. This crime could not be forgiven. He was again immured in the dungeons of the Inquisition, about A.D. 1634, and his heretical books were publicly burnt. Thus was this venerable philosopher, in his old age, harassed and worn out with perpetual citations, and hardships of various kinds, till death terminated his sufferings, and covered his persecutors with perpetual infamy. In 1639, he became blind; and died in the vicinity of Florence, on the 8th of January, 1642, in the seventy-eighth year of his age.

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* "Galileo was twice brought before the Inquisition. The first time, a council of seven cardinals pronounced a sentence, which, for the sake of those disposed to believe that power can subdue truth, ought never to be forgotten—'That to maintain the sun to be immoveable, and without local motion in the centre of the world, is an absurd proposition, false in philosophy, heretical in religion, and contrary to the testimony of scripture. That it is equally absurd and false in philosophy to assert that the earth is not immoveable in the centre of the world; and, considered theologically, equally erroneous and heretical."—Vide *Playfair's Second Diss.* p. 91.

278. DES CARTES, whose name is associated with almost every department of physical and intellectual science, was a contemporary of Galileo; and, being happily placed more out of the reach of the papal hierarchy, could pursue his philosophical investigations with less interruption. In astronomy, he is chiefly celebrated for his application of a high degree of mathematical science to estimate the motions and measure the distances of the heavenly bodies. "He has the merit," says Playfair, "of being the first who undertook to give an explanation of the celestial motions on the principles of geometry," or who formed the great and truly philosophical conception of reducing all the phænomena of the universe to the same law. Kepler had suggested the idea as

a matter of conjecture; but Des Cartes furnished a solution of the problem." But this great philosopher was too much given to theory and speculation to follow the sober track of experimental science. His imagination delighted to rove at large amidst the immensity of the universe. Borne along by an ungoverned fancy, he dreamt of vortices and whirlpools in the boundless regions of space, far beyond the reach of human observation, amidst which other systems and worlds were perpetually performing their grand revolutions, all of which were subject to the same general law, and kept in their due places by the nice adjustment of the centrifugal and centripetal forces, which regulated the movements of the bodies attached to our own solar system. This theory is a proof of the inventive genius and boundless imagination of its author; but it is rather to be remembered among the magnificent speculations of human genius, than the discoveries of physical science.

279. GASSENDI, who was also a native of France, and flourished at the same period with Galileo and Des Cartes, pursued a more safe, though a less brilliant track. He was content with furnishing additional evidence derived from the most careful and accurate observations of the truth of the Copernican system. In the annals of astronomical science, he is chiefly distinguished as the first individual who ever witnessed the comparatively rare phænomenon of the transit of Mercury over the sun's disk. This phænomenon, which Kepler had predicted, but did not live to see, took place in 1631,

and was minutely observed and described by Gassendi. A similar transit of Venus was seen, for the first time, by *Horrox*, a young English astronomer, in 1639, whose early death was deeply lamented by the astronomers of that age, as an irreparable loss to science. Gassendi published, at Paris, in 1654, a volume richly fraught with scientific information, containing the lives of Purbach, Regiomontanus, Copernicus, and Tycho Brahe: soon after the completion of which he died, in the sixty-third year of his age.

280. HEVELIUS flourished about the same time at Dantzic; a laborious and indefatigable astronomer, who is most remarkable for his important improvements in astronomical instruments, his minute observations on the solar spots, on the phases and spots of the moon, on the motions of comets, and on the refraction of light, as it is seen in the phænomena of rainbows, halos, and paraselenes, with many other physical appearances. His astronomical writings were exceedingly numerous, and continue to be held in high estimation. With this celebrated Prussian astronomer may be associated RICCIOLI, his friend and correspondent, who, though belonging to the order of Jesuits, was no enemy to science. This industrious astronomer compiled and published a great work, similar to that of Ptolemy's, entitled, "The New Almagest;" in the execution of which he was greatly assisted by his learned friend and fellow-countryman *Grimaldi*, who first discovered the *inflection* of light.—(*Vide infrà*, § 331.)

SECTION III.

HISTORY OF ASTRONOMY CONTINUED,

From A. D. 1650 *to* 1700.

281. HUYGENS contributed so essentially, during more than half a century, to the advancement both of the abstract and practical sciences, that he may with equal propriety be classed with the first of mathematicians, the profoundest of astronomers, and the most scientific of experimental philosophers. Perhaps his more important discoveries were those which relate to mechanical science, which will form the subject of a future section; but, in the mean time, those which bear upon astronomical science must not be overlooked.

Though the telescope had been discovered nearly forty years, some of its various uses were but little known, till Huygens brought his great practical science to bear on this important instrument. He not only constructed telescopes on a superior principle to any before known, but also suggested the combination of the quadrant with the telescope, and invented a *micrometer* of admirable construction, which, when introduced into his highly improved telescopes, enabled him to measure distances wholly imperceptible to the naked eye. " The magnifying powers of the telescope extend into a line that which to the eye seems but a point; and that line may, by the use of a micrometer, be measured to so minute a space as a *second*." The great utility, therefore, of this invention, soon became apparent in the increased accuracy and certainty with which the astronomer was enabled to measure small angles, and to calculate the parallaxes and distances of the heavenly bodies. But the principal objects to which the astronomical investigations of Huygens appear to have been directed, were the remarkable phænomena exhibited by the planet Saturn. The results of his observations on this planet were published in a distinct work, entitled "Systema Saturninum."

282. The imperfect discovery of the singular configuration of Saturn, by Galileo, was noticed in the last section; but Huygens, having brought the telescope to a higher degree of perfection by his mechanical science, discovered the true form of this planet. He clearly perceived, that instead of the two luminous globes which Galileo imagined to be attached to this planet, he was surrounded by a thin luminous belt or ring, which, being seen in an oblique direction from the earth, assumes an elliptical form; and that when this belt is in such a position that its edge is directed towards the sun, it becomes invisible to us, because a sufficient number of the solar rays are not reflected from it to render it perceptible at so great a distance. Galileo had imagined, in 1615, that he saw two satellites attached to this planet, but afterwards concluded, from their remaining stationary nearly three years, and afterwards becoming invisible, that they were fixed stars; but Huygens, by the aid of a more powerful telescope, most evidently discovered one of these secondary planets, and was enabled to determine its periodical

revolution. To many other discoveries of this great astronomer, may be added that of the true cause of the tides, which he attributed to the combined influence of the sun and moon, though he was unable to demonstrate or explain the fact. After a long life most industriously employed in scientific researches, this illustrious philosopher died in his native city, A. D. 1695.

283. CASSINI the elder, flourished at Paris towards the close of the seventeenth century. He was born at Piedmont, A. D. 1635, and made so great proficiency in mathematical science in early life, as in his fifteenth year to be appointed, by the Senate of Bologna, professor of mathematics in the university of that city. In the following year he made many important observations on a comet then visible, which added greatly to his celebrity as an astronomer. A few years afterwards, he distinguished himself still more in this department of science, by the accurate determination of a meridian line for the newly-erected cathedral at Bologna, and by his calculation of astronomical tables relative to the revolutions of Jupiter's satellites and the periods of their obscuration. These laborious undertakings attracted the attention and admiration of all Europe, and procured for him the appointment of Astronomer Royal in the Observatory of Paris, a station held by himself and his son during more than half a century. Here his opportunities for minute observation being greatly multiplied, he made many valuable discoveries, particularly that of four additional satellites of Saturn, which, reckoned in the order of their respective

distances, are, the first, second, third, and fifth—the fourth having been previously discovered by Huygens. He also discovered and demonstrated the rotation of Mars and Jupiter on their axes, by means of spots perceived on their disks. Nor does it reflect less credit on the genius and industry of this great astronomer, that he succeeded in the solution of a problem relative to elliptic curves, which even the great Kepler had left undetermined. In his latter years, Cassini prosecuted the work which had been commenced by the *Abbé Picard,* a French astronomer of no mean reputation, who had made considerable progress towards measuring an arc of the heavens between Amiens, in Picardy, and Malvoisine, for the purpose of accomplishing an object in which the ancient astronomers had failed—that of determining the exact magnitude of the earth. The elder Cassini died at Paris, A. D. 1712, and was succeeded by his son, who had greatly assisted him in his astronomical researches.

284. Having alluded to the astronomical tables of Cassini, relative to the satellites of Jupiter, it may be proper to introduce here an important discovery to which they led, soon after their publication. ROËMER, a Danish astronomer, perceived a slight disagreement between the times in which the eclipses of the first of these satellites should take place, as laid down in Cassini's Tables, and that of the actual phænomenon. After long attempting in vain to account for this discrepancy, he first conjectured, and afterwards fully demonstrated, that it was occasioned by the time which a ray of light occupies

in traversing the earth's orbit; for the obscuration begins sooner when the earth is in that part of its orbit nearest to the planet, and later when at its greatest distance. By this important discovery, a rule was obtained for the exact measurement of the velocity of light.

285. Several continental astronomers, who flourished during the period under review, have been enumerated; but there were also some English astronomers (exclusive of Sir Isaac Newton), who pursued the same track with scarcely inferior success. Out of many distinguished members of the Royal Society of London, who might be mentioned, three will be selected on account of their specific discoveries in astronomy.

(1.) HOOK, a native of Freshwater, in the Isle of Wight, was one of the earliest members of the Royal Society, and lectured on astronomy in Gresham College. "We are indebted to him," says Bossut, "for the first idea of the system of universal gravitation; but with him it was rather an hypothesis than an ascertained fact." He conjectured that the celestial bodies not only are attracted towards their common centre, but also are mutually attracted towards each other; that, if left to themselves when in motion, they would continue to move in a rectilineal direction; and that the power of attraction is greater or less, in proportion to the relative distances of bodies. It was, however, one thing to conjecture from appearances the possibility or even the probability of these facts, and another to demonstrate them, and discover the *law* by which they are regulated. This honour belongs exclusively to the illustrious NEWTON.

(2.) FLAMSTEED was born in an obscure village of Derbyshire, about A. D. 1646. When the Royal Observatory was built at Greenwich by Charles II., he was appointed to superintend it; and no appointment could have been more congenial to his taste and pursuits. During his residence there, he made an immense number of astronomical observations, the results of which were occasionally communicated to the Royal Society, and first published in their Philosophical Transactions; but afterwards collected into a volume, and published separately, under the title of "Historia Cœlestis." To these were added valuable prolegomena, containing much scientific information, relative to the most recent astronomical discoveries. But the investigation which reflects most credit on the science and industry of Flamsteed, by which he rendered a most important service to astronomy, was, his enlarged catalogue of the fixed stars visible in the northern hemisphere, which amounted to nearly 3000; a far greater number than had been before discovered, and, in many respects, far superior to that which had been collected, a few years before, by Hevelius.

(3.) But it was not sufficient, that the number and positions of the stars which illumine our *northern* climes should be accurately determined: scientific men felt it to be an object of great importance, that similar observations should be made with respect to the *southern* hemisphere. Halley, then a youth of about twenty years of age, undertook and executed this task. In 1676, he proceeded to the island of St. Helena, the place on which he had fixed for the prosecution of his astronomical researches. During his residence on that island, he made as complete a catalogue of the fixed stars visible in that climate, as was then practicable, and grouped them into imaginary constellations, as they were delineated on the celestial globe;—"thus," says Bossut, "having added a new continent to the vast regions of astronomy." During his voyage, this youthful astronomer had the great satisfaction of observing that unusual phænomenon—the transit of Mercury over the sun's disc, on the 3d of November, 1677, the fourth time it had occurred since the invention of the telescope. Three years after his return from St. Helena, when crossing the English channel, on his way from Dantzic, he had the gratification of discovering, at its first appearance, the celebrated comet of 1680, which, on its nearer approach to the earth, spread terror and dismay throughout Europe.

To the above list of astronomers, who flourished towards the end of the seventeenth century, many other distinguished names might be added, particularly those of the two Bernouillis, Richer, and the younger Cassini; but as most of these chiefly flourished after a new and prodigious light had been poured upon the science by the genius of Newton; and since the principal facts of their scientific history are necessarily interwoven with those of our great philosopher, it will be sufficient to notice them incidentally.

SECTION IV.

ON THE ASTRONOMICAL DISCOVERIES OF SIR ISAAC NEWTON.

286. MANY of the greatest events in the history of mankind appear to have originated in comparatively trifling causes. Such were the circumstances which led to the discovery of the great *law of gravitation;* a discovery, which has rendered the name and memory of Newton immortal. Previously to the recital of these, it may not be irrelevant to advert to the advances which had been made in preceding ages, towards this most important discovery. The principle of gravity had been conjectured and hypothetically asserted by some of the ancient philosophers. Pythagoras is said to have taught his disciples, that " the *gravity* of a planet, (though it is doubtful in what sense the term is employed,) is four times that of another at twice the distance." Anaxagoras, (according to the statement of Diogenes Laertius,) held that " the heavens are kept in their place, by the *rapidity* of their revolution, and would fall down, if that rapidity of motion were to cease ;" a conclusion to which he was probably led, not by any distinct conception of the centripetal and centrifugal forces, but merely by an attentive observation of natural phænomena. Plutarch, in some of his philosophical writings, hazards a conjecture that " the moon is kept from falling out of its orbit, by the rapidity of her motion, just as a stone whirled

round in a sling, is prevented by the same cause from falling to the ground." Lucretius, in his celebrated philosophical poem on the "Nature of Things," asserts, that "the atoms of which the universe is composed, would long ere now have united in the centre of the system, if it had not been so infinite as to have no centre." These are the chief, if not the only, notices found in the writings of the ancients, respecting the action of gravity on the celestial bodies, which are but to be accounted the reveries of ingenious men, not in possession of data on which to found any conclusive reasonings.

287. Advancing to the period under review, it will be found, that several important steps had been taken towards the discovery of the law of gravitation, before the time of Newton. Copernicus asserts, in his treatise on the "*Celestial Revolutions*," that, in his opinion, *gravity* is nothing but the natural appetency of the parts of the earth to each other, given by the providence of the Supreme Being, that by uniting together, they may assume the form of a globe;" and he adds a conjecture, that "this same affection belongs to the sun, the moon, the planets, and the fixed stars, all of which are also spherical." Kepler, in his celebrated work on the planet Mars, takes a yet more important step towards the discovery of the great fact in question; for he there treats of "*gravity*, as acting from planet to planet, and particularly from the earth to the moon." Yet, with all this, he does not appear to have so much as conjectured, that the

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was yet no more than a conjecture, of the truth or falsehood of which, the measurements and reasonings of geometry could alone determine.*

288. The apparently fortuitous circumstances, which led to the train of investigations terminating in this brilliant discovery, are thus described by one of the biographers and an intimate friend of the great astronomer. Having retired for a short time from Cambridge, on account of the plague of 1665, he was sitting alone in his garden, and began to speculate on the power of gravity. This power, he reflected, is not sensibly diminished at the greatest elevation from the earth, as on the summits of the loftiest edifices, or the highest mountains; it must, therefore, extend farther than is generally supposed. Why not as high as the moon? and, if so, her motion must be affected by it,—will this account for her revolution and orbit? If to the moon, why not to the planets, and the whole solar system? and, if so, will this explain their motions round the sun? Following up this train of thought, by laborious mathematical calculations, he found, on comparing the relative distances of the several planets from the sun, that if any power, like that of gravity, retained them in their courses, it must decrease in the duplicate ratio of the increase of their distances. But being impressed with the idea which then generally prevailed, that the orbits of the planets were concentric circles, he found that his calculations did not exactly correspond with what he then supposed

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* Playfair's Second Dissert. ut suprà, p. 66---69.

to be the truth. Discouraged by this difficulty, he was on the point of abandoning altogether his train of speculations, as merely hypothetical and fallacious; or, at least, he felt anxious to discover some other force, which, combining with that of gravity, might explain the supposed phænomena. But, happily, having been led to the discovery, by other inquiries, that the motion of the earth is elliptical and not circular, a new light seemed to break in upon his mind; he saw at once the connexion between this discovery and his former researches into the operation of the law of gravity; renewed and pursued those researches more vigorously, accompanied with accurate mathematical calculations; nor stayed in his progress, till he arrived at the important results developed in his celebrated "*Principia.*" "This important treatise," says Pemberton, "full of such a variety of profound inventions, was composed by Newton from scarcely any other materials than a few propositions previously established by himself, relative to the motions of the primary planets, in the space of one year and a half."* The publication of this work, in 1687, marks a great æra in the history of human knowledge, and speedily effected a complete revolution in the philosophical opinions and pursuits of mankind; withdrawing them from the vortices of the Cartesian philosophy, to investigate the laws of matter and motion, as exemplified in the entire system of nature.

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* Vide Pemberton's View of Sir Isaac Newton's Philosophy, Preface.

289. The great excellency of the *Newtonian philosophy*, (for such it may be most fitly designated,) consists in the solid basis of mathematical demonstration on which its fundamental principles rest, and the innumerable physical proofs by which they are illustrated and confirmed. The great fact of the mutual attraction of bodies, had been previously ascertained; Kepler's celebrated laws, and Huygens' mechanical experiments, had gone far towards determining the ratio of this tendency; but the demonstration of the exact measure of the centripetal and centrifugal forces, and the phænomena resulting from them,—the proof that the law of gravitation pervades the whole system of nature, applying alike to the mightiest masses and the minutest particles of which it is composed,—the accurate delineation of the motions and orbits of the heavenly bodies, in conformity with this gravitating principle—all these are the glory of the new philosophy of which Newton was the founder. The demonstration of this astonishing fact having been obtained by the new method of analysis, it was the next object of this great practical philosopher to determine the extent of this mysterious law of nature, by the most careful astronomical observations and to prove by *experiment*, that those phænomena occurred which science had taught him to expect, and that the consequences which had been anticipated, really followed in the physical system. On the principle of the mutual attraction of the heavenly bodies, all those irregularities, or rather inequalities, of motion, observable in the planetary revolutions, which had long perplexed

astronomers, were satisfactorily explained — such as the *librations* and *evection of the moon*—the *disturbing forces,* mutually exerted by primary and secondary planets—the *theory of the tides*—and, above all, *the precession of the equinoxes*—with many other phænomena, which now constitute the chief objects of *physical astronomy.* Nor was it among the least of the discoveries resulting from the demonstration of this law, that the true *configuration of the earth* was ascertained, and some difficult problems were solved, connected with that fact; such as the cause of the slower vibration of the pendulum, and the diminished intensity of attraction, at the equator than at the poles.

290. But perhaps the most astonishing consequence of the discovery of the law of gravitation was, that it enabled the astronomer to estimate the *magnitude and density of the planets.* A rule of universal application was obtained, which was briefly this; "that in any two bodies (their distances being the same) their power of mutual attraction is in proportion to the quantity of matter they respectively contain; or, in other words, that they have a tendency to approach each other with velocities which are inversely as their quantities of matter." Applying this rule first to the moon, as the nearest of the planetary bodies, and subsequently to those more remote, Newton deduced, from an accurate observation of their distances compared with their velocity of motion, the mean density of each. Every succeeding year, and all the accumulated facts of modern science, have served but to confirm the

truth, and extend the application of these incontrovertible principles, and heighten our admiration of the genius and science of their inventor.

291. The preceding summary of the astronomical researches and discoveries of our great philosopher, cannot be more appropriately concluded, than by the following brief extract from another valuable work of the late Professor Playfair, in which they are all happily brought to bear on one point, and their mutual relation is distinctly traced.

"Thus it is found, that the laws of motion and the general properties of matter are the same in the heavens and on the earth; that the elliptical motions of the primary and secondary planets; the small deviations from those motions, whether in the places of the planets or in the form and position of their orbits; the facts which concern their figures, their rotation, and the position of their axis; and lastly, the oscillation of the waters which surround the earth, are all explained by *one principle*, 'that of the mutual gravitation of all bodies, with forces *directly* as their quantities of matter, and *inversely* as the squares of their distances.' The existence of this force was not assumed as an hypothesis, but deduced as a necessary consequence from the general facts or laws discovered by Kepler. We have thus arrived at the knowledge of a principle which pervades all nature, and connects together the most distant regions of space, as well as the most remote periods of duration."*

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* Playfair's Outlines of Nat. Philos. II. p. 339.

II.

DYNAMICS AND MECHANICS.

SECT. I.

ON THE PROGRESS OF MECHANICAL SCIENCE DURING THE SIXTEENTH CENTURY.

292. THE connexion is so intimate between all the practical sciences, that it might reasonably have been expected, (and facts have abundantly verified that expectation,) that the æra in which any one of these has remarkably flourished, would be characterized by a proportionate improvement in all the rest. It was scarcely possible that such brilliant discoveries should have been made in astronomy, as have been sketched in the preceding sections, without a simultaneous and corresponding progression in all the departments of *mechanical science*, whether it be regarded in the more abstract form of *dynamics*, or in the practical application of those general principles by various kinds of machinery. In like manner, we are prepared to expect that the same individuals, who have immortalized their names by astronomical researches and discoveries, would be those who occupy a prominent place in other departments of physical science, and especially in one so nearly allied as *mechanics*. That a more

distinct conception may be formed, by the juvenile reader, of the two great divisions of modern science, the history of which is now to be sketched, during a period in which they were rapidly progressive, it may not be improper just to state that the term *dynamics* is employed to describe that branch of physico-mathematical science, which treats abstractedly of the laws of matter and motion; or, in other words, which teaches the *doctrine of moving forces: mechanics* denotes that division of the science which reduces to practice the principles of dynamics, and illustrates them by experiment. The inventions of mechanical philosophy serve to exhibit the manner in which the moving forces act, the laws by which that action is regulated, and the effects that must necessarily result in any given case from their practical application.

293. It has been already stated, (§ 93,) that dynamics, considered as a science, was wholly unknown to the ancients. Nor did any material alteration take place in that of mechanics, from the æra of Achimedes, to the middle of the sixteenth century. The principles laid down by that great practical philosopher, and exemplified by his stupendous machinery, had been applied to various uses by a few scientific men, such as Gerbert, Friar Bacon, and some others, who lived, at distant intervals, during the middle ages. But no new discovery had been made,—no new theories invented,—no new problems solved, through the whole of that long series of years. The first who can be said to have taken a single step in advance, was *Guido Ubaldi*, an Italian mathematician, who published, in 1577, a treatise on "Statics," in which he carried somewhat farther than the ancients had done, the problems relative to the equilibrium of bodies, by combining the pulley and lever, shewing their mutual relation and the principles common to both. Next in the order of time occurs *Stevinus*, a Flemish mathematician and natural philosopher, who, a few years after, succeeded in establishing some important principles with reference to the inclined plane. Though the ancients had discovered this mechanical power, they were comparatively ignorant of its nature and properties; and seem to have had no conception of the important advantages which modern science had derived from it. Stevinus was the first who made known the laws of equilibrium, as it respects bodies placed on the inclined plane, by accurately determining the power requisite to sustain or to move a body thus situated at any given angle, or in any degree of inclination. The reasonings and experiments by which he arrived at this useful discovery are fully developed in his posthumous works, which were collected and published by Albert Girard, A.D. 1634.

294. The theory and laws of motion must ever form an important branch of philosophical investigation. Of this fundamental branch of physical science, the philosophers of Greece and Rome, as well as the scientific Arabians of the middle ages, were almost wholly ignorant. They do not appear to have proceeded further than to the estimate of *uniform motion*, which, by the aid of mathematical

science, they were able to determine with tolerable accuracy. But unacquainted as they were with the great cause of *accelerated* or *retarded* motion, it was not to be expected that they could estimate the effects resulting from that unknown and mysterious agency. But from the time in which true philosophy revived under the auspices of such men as Copernicus, Kepler, and Galileo, this department of mechanical philosophy began to be cultivated with distinguished success. A memorable and highly important revolution was effected in the practical sciences, chiefly by the inventive genius and indefatigable labours of the latter of these great philosophers. From the æra in which Galileo flourished, (which was the close of the sixteenth and the beginning of the seventeenth centuries,) the combined application of geometrical and experimental science, to the solution of natural phænomena, may be dated.

295. To enumerate all the valuable discoveries of this great practical philosopher, in connexion with this science of mechanics, would far exceed the assigned limits of the present work. A few of the more important, on which his posthumous fame chiefly rests, will be selected.

(1.) The researches of Galileo, in conjunction with those of Kepler, led to the discovery of the laws of *uniformly accelerated motion;* a discovery which is the more interesting as an important step towards the development of the great law of gravitation. The great law established by Galileo on this subject was, that, "in bodies falling freely, that is, having no force acting upon them but that of gravity, and, consequently, in which the accelerated motion is uniform, "*the spaces passed over are as the squares of their times.*"

(2.) Nearly allied to the preceding was the discovery, that bodies of different densities fall from the same height in times so nearly equal, that the difference might reasonably be ascribed to the resistance of the air alone, and, consequently, that in all bodies falling freely, "*the increments of velocity are equal in equal times.*" These principles were afterwards applied to the descent of bodies on inclined planes, and other cases in which different forces were combined.

(3.) Hence he was led to investigate the laws of motion as applied to projectiles, respecting which he demonstrated that the path described by a heavy body, projected with any velocity and at any degree of elevation, must be a parabolic curve, since two forces act upon it, the one equable along the line of projection, the other uniformly accelerated towards the earth; thus proving that he was not unacquainted with the doctrines, to which, in modern times, the names of *Composition of Forces,* and *Virtual Velocities,* have been given.

(4.) To this illustrious philosopher is also attributed the first indistinct conception and practical illustration of what is now termed "the *law of continuity,*" by which is intended, the fact so fully established by modern science, that all changes of motion are effected gradually, and not on a sudden; so that no body can pass from one line of direction into another, without describing a curve, and taking in its motion every possible direction from the one to the other. The important bearing of this law, in explaining the phænomena of deflecting and central forces, renders the discovery, however imperfectly made, highly interesting, and of great value.

(5.) The preceding discoveries, it will be perceived, relate to dynamics properly so called, and comprehend almost the entire range of scientific investigations connected with that science. One or two may be added, which are purely mechanical. In a treatise on "Statics," published by Galileo, A.D. 1592, he fully established, both by facts and reasonings, two fundamental laws on mechanics, viz. that "*the power and weight are in an inverse ratio;*" and that "*what is gained in power is lost in time.*" These facts, simple as they may appear, led to the train of scientific discoveries enumerated above, relative to the doctrine of moving forces in general.

(6.) Finally, from observing attentively the vibrations of the lamps suspended in the cathedral of Pisa, this ingenious philosopher was led to the discovery, that "*the vibrations of a pendulum,* whether moving in a greater or less area, *are performed in equal times.*" This was a most important step taken towards the accurate measurement of time, on which account some have ascribed to Galileo the first invention of chronometers and clocks. The principle on which they must necessarily be constructed, was undoubtedly discovered by him; but its mechanical application was not as yet discovered.

296. It is easy to conceive how the ardour of Galileo, in pursuing this train of investigations, must have been stimulated and increased by the obvious connexion between them and the then newly discovered system of astronomy. For though he was little aware of their extensive application, yet his own researches, and those of his illustrious contemporary Kepler, sufficiently proved that such a relation existed. They could not fail to perceive that the principles they had mutually established with reference to the portions of matter immediately within their observation, might also serve to explain the motions of the heavenly bodies. Nor could they be ignorant of the fact, though as yet unable fully to demonstrate it, that the same laws which regulated the path of a projectile, would account for the revolutions of the planets and their satellites in their several orbits, and in revolving round their common centre.

297. This rapid sketch of the progress of physical science during the sixteenth century cannot be concluded without adverting to one of the most illustrious philosophers of that or any other age; who, if he did not, like those enumerated above, employ himself in laborious processes and profound investigations into the phænomena of nature, yet accomplished more, since he pointed out the true method of philosophizing, and thus prepared the way for future and more important discoveries. The personage referred to is LORD BACON, who flourished at the close of this century, and who will be more distinctly noticed under the head of "*intellectual philosophy.*"

This profound philosopher, conceiving most justly that the principal sources of ignorance and error, or rather the principal hindrances to the progress of true science, were the neglect of proper means to enlarge our knowledge, and the presumptuous attempt to theorise and speculate beyond the power of our limited faculties, pointed out the method which alone can be safely pursued, whether in physical or intellectual science,—that of proceeding cautiously, step by step, on the sure basis of experiment, till we arrive at general principles, as the result of our inquiries and observations.

The great principle which characterizes the philosophy of Lord Bacon, to which he himself rigidly adhered in his scientific researches, and which was still more practically regarded by Sir Isaac Newton, was, upon no consideration, to indulge conjectures concerning the powers and properties and laws of nature, but to make it our endeavour to search out by an *inductive* process the laws by which the constitution of nature is regulated. For we can only argue from that which is known to that which is unknown. The qualities of bodies become known to us only by experiments; nor have we any other way of finding the properties of bodies beyond the reach of actual experiment, than by drawing conclusions and deductions from phænomena actually observed. To this principle of physical investigation, it is added, as a needful and salutary caution, that the facts from which such conclusions are drawn must be numerous, and that due regard must be paid to objections which may be raised against them.

A cursory view of those parts of Lord Bacon's valuable writings, which belong to the department of physical science, will sufficiently illustrate the nature and use of these fundamental principles, and justify the application to him of that truly honourable distinction, by which he is more ennobled than by all the splendid titles affixed to his name, or the dignified offices he sustained—THE FATHER OF EXPERIMENTAL PHILOSOPHY.

SECTION II.

HISTORY OF DYNAMICS AND MECHANICS CONTINUED DURING THE SEVENTEENTH CENTURY.

298. TORICELLI, the pupil of Galileo, (whose fame chiefly rests on his discovery of the weight of air by means of the tube which still bears his name,) contributed also to the advancement of mechanical science, by his minute experiments and accurate calculations respecting the velocity of falling bodies, and the position of the centre of gravity. The results of his observations on these subjects were communicated to the public in his well-known treatise, " De Motu gravium naturaliter accelerato." "To this ingenious man," says Playfair, " we are indebted for the discovery of a remarkable property of the centre of gravity, and a general principle of great utility, with respect to the equilibrium of bodies; which is, that if in a system of bodies, the centre of gravity is so fixed that it can

neither ascend nor descend, those bodies will remain at rest. Scarcely is there a principle of greater practical utility than this in the whole range of mechanical science."

299. The next important step towards the improvement of practical mechanics was taken by the celebrated Des Cartes, not indeed without a mixture of error, as is usually the case in the earliest stages of all the experimental sciences. Setting out in his researches with the metaphysical notion, that the same quantity of absolute matter always exists in the world, he applied this principle, which is partly true and partly false, to the several cases of *friction*, *percussion*, and *collision;* and concluded that it equally applied to them all, in all possible circumstances. The conclusion to which he was led, by his scientific investigations on this subject, was, that in the three several cases of a body impinging against another at rest, or moving in the same direction with different velocities, or moving in opposite directions, the result would be, that the sum of the motions after such collision, would be equal to the sum of the previous motions. This conclusion was just with regard to the two former, but it is contrary to fact when applied to the latter of the above-mentioned cases. To this great philosopher is also attributed the more complete demonstration of the principle of the composition of forces, as it is seen in the curvilinear motion of projectiles, and the necessity of a deflecting force continually acting in conjunction with that of gravity to produce such a result. It is further evident from those parts of

his philosophical writings, which relate to mechanics, that he explained more fully than any of his predecessors had done, the true nature of the centrifugal force, and ascribed that force to its true cause, viz. the tendency of matter to uniform and rectilineal motion.

300. The mixture of theory with experiment tended greatly to diminish the value of Des Cartes' philosophical investigations. But we next meet with a scientific philosopher of a widely different character, who rigidly adhered in all cases to the evidence of facts. This was the distinguished Dutch philosopher Huygens, who was unquestionably the greatest mechanician of his age. Following up, with steady perseverance and unabated ardour, the track marked out by preceding philosophers, he succeeded in making many discoveries of the utmost practical importance. Among others, he ascertained the true nature of the cycloidal arc, described by a pendulum, and applied it to the equal division of time. He fully demonstrated, that from whatever part of a cycloidal curve a heavy body falls, it always arrives at the lowest point of that curve in the same space of time. By this means the relation was discovered between the length of a pendulum, and the time of its least vibrations; and thence followed the rules necessary to be observed in the manufactory of clocks, and upon which their accuracy chiefly depends. This very remarkable proposition would alone have been sufficient to render the name and memory of its inventor illustrious. But, in addition to this, many other valuable papers

were communicated by him to the philosophical societies of which he was a distinguished member, relative to the central forces in general, and particularly those of percussion and oscillation.

301. A controversy arose about this period, in which posterity is little concerned, but which at the time was fiercely contested. The question related to the honour of the invention of the pendulum, as a rule for the measurement of time. The continental philosophers claimed the honour of this discovery for Galileo and Huygens. Dr. Hooke, an English mathematician and astronomer, claimed it for himself. It is certain, that not these alone, but many other men of science in different parts of Europe, were, at the time of this discovery, investigating the nature and properties of the cycloid; and, being employed in the same researches, it is not improbable that they may simultaneously have hit upon the same discovery. Valuable papers were transmitted continually to the respective philosophical institutions of Europe, from the most eminent scientific philosophers of the age, such as Wallis, Sir Christopher Wren, Huygens, Hooke, and others, closely connected with the object of this discovery, and from each of these valuable hints may have been derived. The conclusion, however, to which we are led by the detailed narrative of this controversy is, that Huygens and Hooke contributed most essentially to the accurate measurement of time—the former, by his discovery of the laws of pendular motion—the latter, by his invention of the use of a metallic spring in regulating the movements of a watch.

In addition to the preceding highly important discoveries of Huygens, may be mentioned one which is indisputably his own, and without which all the rest had been comparatively useless. This was the solution of the problem by which to find the centre of oscillation; a solution which, in the opinion of a distinguished modern writer, whose authority none will venture to dispute, was "the most difficult of any which preceded the invention of fluxions."*

302. The above series of mechanical researches comprehends the principal of those which engaged the attention of scientific men before the discovery of the "analysis of infinites." There were many fellow-labourers in this department of science, who might have been enumerated, amongst whom the honour of carrying forward the new science of dynamics must be divided. Among these were, Wallis and Pascal, Roëmer and Leibnitz; but as their merit chiefly consists in following up the investigations of others, rather than striking out a new path, it is not necessary to advert to them more particularly in this department of philosophy. It should however be stated, that while these general laws of mechanics were receiving additional confirmation from various quarters, practical men were actively employed in bringing them to bear upon the purposes and pursuits of social life, by the invention of new machinery, or the improvement of instruments already in use. To this period may be referred the construction of machines, in which the laws of equilibrium and the doctrine of moving forces were strikingly exemplified and applied to important uses; such as, the improvement of *navigation*, by calculating, with greater exactness, the force of wind on distended sails—the construction of *mills*, worked by wind or water; and especially the *steam-engine*, the first conception of which seems to have been suggested by the ingenious *Marquis of Worcester*, in his experiments made A. D. 1660, and the first rude model of which was constructed by a French mechanic towards the close of the century.

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* Playfair's Dissertation.

303. After the discoveries of Newton, (which it will be proper, on account of their magnitude and importance, to make the subject of a distinct section,) the science of mechanics advanced rapidly towards its present state of perfection. In 1687, *Varignon* made an attempt to exhibit the combined influence of all the mechanical powers, in a treatise entitled "Project of a new System of Mechanics." In 1695, *La Hire* published a similar work, illustrative of the laws of equilibria, as applied to all kinds of machinery; and about the same period, as well as long afterwards, the *Bernoullis* enriched the science with many valuable writings on "statics," containing the results of their profound investigations into the properties of matter and laws of motion. The following extract from Playfair's Review of the History of Mechanical Science, at that period, exhibits at one view the principal objects of investigation, which then occupied the attention, and called forth the energies of the most enlightened

philosophers of Europe:—"Such problems as that of finding the centre of oscillation—the nature of the catenarian curve—the determination of the line of swiftest descent—the retardation produced to motion in a resisting medium, whatever might be the degree of that resistance—the determination of the elastic curve, or that into which an elastic spring forms itself, when a force is applied to bend it—all these were problems of the greatest interest, and were now resolved for the first time; the science of mechanics being sufficient, by means of the composition of forces, to find out the fluxionary or differential equations, which expressed the nature of the gradual changes which in all these cases were produced; and the calculus," (or mathematical process then newly invented,) "being now sufficiently powerful to infer the properties of the finite, from those of the infinitesimal quantities."*

SECTION III.

ON THE MECHANICAL DISCOVERIES OF SIR ISAAC NEWTON.

304. THE first part of the celebrated "Principia Mathematica" of Sir Isaac Newton, relates exclusively to the subject of this section; and, perhaps, no better mode can be adopted of exhibiting a summary view of this division of his physical

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* Vide Playfair's Second Diss. and Encyc. Britt. New Sup. Vol. IV. pp. 41, 42.

researches and discoveries, than presenting an outline of the principal contents of that work, as far as they relate to mechanical philosophy. The chapters to which we especially refer, are those which treat of the properties of matter—the laws of motion—the composition of forces, and their influence on bodies variously circumstanced—together with the properties and use of the mechanical powers, whether separately or in a state of combination. To this memorable work, which may justly be accounted the *chef d'œuvre* of modern science, and an imperishable memorial of the mighty genius of its author, it is requisite to refer the reader for the full development of principles, which can be exhibited here but in faint outline.

305. The treatise commences with a series of definitions explanatory of the terms about to be employed; such as, the *quantity* of *matter* and of *motion*—the different kinds of *forces*, whether that of *inertia*, or the *centripetal*, or any other externally impressed—*time* and *space*, both *relative* and *absolute;* with some other essential or accidental properties and adjuncts of matter. The author next propounds, in the form of *axioms*, his three celebrated Laws of Motion; which, as forming the basis of his entire system of mechanical philosophy, it will be proper distinctly to state.

(1.) That all bodies have such an indifference to rest or motion, that if at rest, they remain so till disturbed by some force acting upon them; or if in motion, they continue to move forward in a rectilineal direction, and with uniform velocity, unless turned aside, stopped, or impeded in their course, by some new power impressed upon them.

(2.) That the change effected in the motion of any body (whether its transition be from rest to motion, or from motion to rest, or from one degree of motion to another), is always proportional to the force impressed, and in the direction of that force.

(3.) That action and reaction are equal; or, in other words, that if one body act upon another, the quantities of motion produced are equal in the body acting, and in that acted upon.

Of each of these fundamental laws, mathematical proofs and practical illustrations are given, sufficient to place them beyond the possibility of reasonable doubt.

306. This solid and immoveable basis having been laid, the illustrious author proceeds to raise upon it the whole structure of dynamic and mechanical science. These principles are applied to the solution of the phænomena of uniform, accelerated, and retarded motion—of motion produced by percussion, collision, or friction—to projectile, deflecting, and central forces—to the perpendicular, oblique, or curvilinear ascent and descent of bodies—to the cycloidal arch, and the properties and laws of pendular motion, whether vibrating in a circle or a cycloid—to the centres of gravity, oscillation, and percussion—to the line of swiftest descent; with many other objects of investigation connected with the absolute or relative motion of bodies, and their several ratios of velocity. From the simplest elementary truths, this philosopher proceeded, by a train of inductive reasonings, to the investigation of forces acting under all conceivable circumstances, either uniformly or at intervals, either in an increasing or a decreasing ratio, either freely and without resistance, or when counteracted by other forces acting in contrary directions. In all these or any other supposable cases, either of simple or compound forces, he calculated the velocity with relation both to time and place—the distances passed over in any given time—the magnitude and density of the moving bodies, &c. Such are the principal subjects of profound investigation to which the facts and reasonings of the "*Principia*" refer, and to which also we are chiefly indebted for the brilliant discoveries of modern astronomy.

307. From these mere abstract principles, a transition is made to the *mechanical powers;* when the author describes their nature, calculates their effects in any given case, and arrives at some general laws respecting them. The varieties of the lever, the pulley, the wheel and axis, the screw, the wedge, and the inclined plane, are minutely described, and the force of each is estimated, together with the laws of equilibrium respecting them. These were, however, but elementary to his great design,—that of applying the principles of mechanical science to the motions and revolutions of the heavenly bodies, and the entire system of the universe. With unutterable delight must this mighty genius have perceived, as he pursued his wondrous track, and penetrated farther and deeper into the mysteries of nature,

that all the vast machine was put in motion, and all those motions were regulated, by one great, universal, mysterious agent, to which was given the name of *gravitation,* but which is, in reality, no other than the power of Deity pervading all his works, and constantly excited to preserve the order and harmony of the material universe. This constitutes the principal glory of this truly philosophical system. The grand and comprehensive view it exhibits of the mechanism of the natural world, is its distinguishing excellency, which has been thus happily characterised by Playfair :—" It is seen in the new application of mechanical reasoning, by transferring it from earth to heaven ; from small portions of matter to the mechanism of the universe — in the reduction of questions concerning force and motion, to geometrical problems, and thus rendering them no longer subjects of speculation, but capable of proof — and in the mensuration of mechanical action by its nascent effects, applying the same principles and general laws to the calculation of the greatest, as well as the least moving force."*

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* Vide Playfair's Dissert. ut suprà.

III.

HYDRODYNAMICS AND PNEUMATICS.

SECTION I.

HISTORY OF HYDROSTATICS, &c. CONTINUED,

From A. D. 1600 *to* 1660.

308. THE general principles which have been adverted to under the head of Mechanics, could scarcely fail to direct the attention of the philosophers of Europe to kindred branches of physical science. Applicable as those principles were to *fluid* as well as *solid* bodies, it was to be expected that, while some constructed machines illustrative of the moving forces, or the laws of equilibrium with reference to solids, others would direct their researches to the influence of the same causes of motion or rest on the two species of fluids with which we are most familiar — namely, *air* and *water*. Without attempting to exhibit in detail *all* the discoveries made by scientific men, at the memorable period under review, in these comprehensive divisions of natural philosophy, a brief account will be given in the present section, of the most important and useful of those scientific developments.

And here (as in the former case) it is requisite to commence with *Stevinus*, of whose personal history little is known, but who contributed in no inconsiderable degree, both by his experiments and writings, to the advancement of the practical sciences. In hydrostatics, he is said to have first made the discovery, that " the pressure of a fluid on the bottom of a vessel is always as the product of the altitude and the area of the base, whatever may be the shape of the vessel, or whatever quantity of the fluid it may contain." The practical demonstration of this theorem was, at the time of its discovery, little regarded; its importance was not felt, nor were its extensive bearings perceived: but it has been long since classed with the fundamental principles of hydrostatic science. Though the honour of this discovery unquestionably belongs to Stevinus, he was little aware of its intimate connexion with all the principal phænomena relative to the equilibrium and pressure of fluids; and especially with its application to what has since been called *the hydrostatical paradox*. It remained for the vigorous and comprehensive genius of Pascal to develop its true nature and extent. In a treatise, published by that enlightened philosopher a short time before his death, on the "*Equilibrium of Fluids*," he availed himself of this principle, (which Stevinus had previously demonstrated,) for the purpose of proving *the equal pressure of fluids*, while in a state of rest, and to explain the apparent paradox, that a slender column, pressing on the same base, will hold in equilibrio a mass of the same fluid of equal height, however disproportionate their relative quantities might be.

309. While these advances were making by slow and almost imperceptible degrees in that branch of *hydrodynamics*, to which the name of *hydrostatics* has been given, because it relates to the phænomena of *fluids at rest*, some curious and useful experiments were carrying on with reference to that kindred branch of the science, which treats of *fluids in motion*, technically termed *hydraulics*. About A.D. 1628, Castelli, (who had been a disciple of Galileo, and had imbibed from his illustrious preceptor an ardent desire of knowledge, and unwearied diligence in the investigation of natural phænomena,) published a small but valuable treatise, containing the results of his observations on the phænomena of fluids in a state of motion; the degree of resistance they oppose to solid bodies immerged in them, or floating on their surfaces; and the impetus acquired by confinement and compression. The chief object of Castelli's treatise was to explain some of the phænomena of water flowing in natural or artificial channels, of whatever dimensions; and the general principle established was, that "the velocities of a stream at different sections, made perpendicular to the line of its motion, are in the inverse ratio of the surfaces of those sections. Toricelli, another and a far more celebrated disciple of Galileo, carried farther this train of physical investigations, by explaining the theory of fountains and jets, or of fluids spouting in any direction through small apertures. On this subject he demonstrated, that "water issues from a hole in the side or bottom of a vessel, with the velocity which a

body would acquire by falling freely or perpendicularly from the level of the surface to that of the orifice." With regard to fountains, this most ingenious philosopher proved, that water thus compressed will rise so nearly to the height of the reservoir with which it is connected, as to prove the truth of the general theorem stated above, due allowance being made for friction and the resistance of the superincumbent column of air. The results of these investigations into the laws of spouting fluids were communicated in a work, on "the accelerated Motion of Heavy Bodies," published about A.D. 1644.

310. But these researches and discoveries, though in themselves highly interesting, and in their consequences of great practical utility, constitute a very small part of the benefits conferred on succeeding ages by Toricelli. There is one which cannot fail to immortalize his name and memory—his demonstration of the pressure and weight of air by means of the *barometer*, or, as it is sometimes called, *the Toricellian tube*. The following is a brief outline of the history of this important invention.—Some Florentine engineers inquired of Galileo the reason why they were unable, by the action of a common pump, to raise water more than thirty-two feet above the level of the well or reservoir with which it was connected. Unable to give a more satisfactory reply, he answered, agreeably to the prevailing philosophy of that age, that it was "*because nature abhorred a vacuum*." But this great philosopher was too enlightened and scientific a man to feel

perfectly satisfied with the reason which he had assigned, and commenced a series of experiments with the hope of ascertaining the true cause of the phænomenon in question. He was not, however, so fortunate as to succeed; but, soon after his death, Toricelli pursued the investigation with complete success. He began with ascertaining the comparative density of air and mercury, which he found to be in the proportion of one to fourteen; then, by repeated experiments, he ascertained that mercury would not naturally rise more than $\frac{1}{14}$th part of thirty-two feet above its level. The conclusion was obvious, that the same cause, whatever it might be, must operate in both cases; and the solution of the phænomenon which immediately occurred to this ingenious philosopher was, that the weight of the column of fluid in each case prevented its higher elevation; and that there was some other force which then held it in equilibrio. What could this be, but the weight of the atmospheric air resting on the surface of the fluid? From these previous steps, he was led to infer, that the weight of a column of water thirty-two feet high, or of quicksilver fourteen times less, is equal to a column of atmospheric air, reaching from the earth's surface to the upper extremity of that fluid—thus not only proving the *weight and pressure of air*, but furnishing a rule by which its comparative density may be estimated.

311. The Cartesian philosophers took alarm at the discovery of a fact so fatal to their favourite dogma of "Nature's abhorrence of a vacuum." Some questioned the accuracy of the experiment; others denied the legitimacy of the conclusion deduced from it. But in this case also, the inventive genius of Pascal promoted the advancement of science, and led to the triumph of truth over deeply-rooted prejudices. Causing a barometer, constructed agreeably to the directions of Toricelli, to be conveyed to the summit of Puy de Dome, a mountain in Auvergne, he found that the mercury descended, as the barometer was more elevated; that is, in exact proportion as the column of air which pressed upon it was diminished in altitude and weight. It was immediately apparent, that this additional fact would furnish a rule by which to measure the height of mountains; a purpose to which it has, in modern times, been most successfully applied. To the honour of Toricelli, it should be added, that so far was he from being elated with his success in having made so curious and important a discovery, that he felt and expressed the deepest regret, that it had not fallen to the lot of his beloved preceptor, Galileo, to make the first development of this great physical fact.

SECT. II.

HISTORY OF HYDRODYNAMICS AND PNEUMATICS CONTINUED,

From A. D. 1650 *to* 1700.

312. THE invention of the barometer, and the demonstration thus obtained of the gravity and

pressure of air, led the practical philosophers of Europe into new trains of investigation. They endeavoured, by different modes of operation, to remove more effectually the pressure of air, and produce a more perfect vacuum than had hitherto been obtained. With this view, hydraulic engines of various kinds were constructed, for the purpose of raising water to any degree of elevation which might be required, or increasing the velocity of its motion. Of this description were forcing pumps, syringes, and many similar contrivances of great practical utility. But among all the inventions of this period, none has contributed so effectually to the advancement of science, as that of *the air-pump.* The honour of this invention unquestionably belongs to OTTO GUERICKÉ, a counsellor of Magdeburg, who flourished about A.D. 1654. The first intimation was given of this important discovery in the "*Technica Curiosa*" of *Schottus,* who was at that time professor of mathematics in the university of Wirtemberg. From this authentic source of information we learn, that the first attempts of Guerické to produce a vacuum were extremely rude and imperfect. He filled a barrel with water, from which he drew part of the fluid by means of a common sucking pump, but had not proceeded far in the operation, before the weight of the external air burst the vessel with a violent explosion, thus "proving the weight of air as effectually by the failure of his experiment, as he could have done by its complete success." The experiment was frequently repeated, and the result was uniformly the same; until a rude machine was constructed with a glass globe affixed to it, which resisted the pressure of the air, and enabled him to obtain the desired end. Imperfect as was the instrument employed, it led to the discovery of another fact, highly important in the science of pneumatics, namely, the great expansibility and *elasticity of air.*[*]

313. Doctrines so new, and facts so surprising and almost incredible as those now developed, could not fail to awaken the ardour of scientific men. The most distinguished members of the philosophical societies then recently established in Europe, made them the frequent theme of their correspondence, and the object of their diligent research. None, however, pursued this new train of experiments more successfully than the excellent BOYLE, a man distinguished still more by his fervent piety, than by his philosophical science. This great experimentalist had been attempting, from the time of Toricelli's discovery of the weight of air, to make observations on the appearances of bodies of various kinds when freed from the pressure of air, and had devised numerous expedients by which to obtain a vacuum; but finding these processes laborious, and the results uncertain, he hailed with delight the intelligence of Guerické's discovery, when announced by the publication of Schottus; and though

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[*] The subsequent improvements made in the air-pump by this ingenious philosopher, and the successive steps by which he was led onward to higher and more important discoveries, will be found detailed at considerable length in the Encyc. Britt. Vol. XV. (article Pneumatics) § 91—95; and also in many other modern treatises on Pneumatics.

no description was given of the Magdeburg instrument, immediately set about the construction of an air-pump, on a plan contrived by himself; so that he may be accounted the *second inventor* of that useful machine. Successive improvements were added year by year, which were either the fruit of his own inventive genius, or suggested to him by his learned friends; till the instrument had arrived at a considerable degree of perfection. The philosophical works of Boyle contain an immense number of experiments made by him, which were intended to prove the expansibility of air — its power to dissolve water, to extinguish light, and to produce combustion, — its necessity for respiration and vegetation, with innumerable other facts of great practical importance.

314. The experiments of Toricelli, Pascal, Huygens, Boyle, Hooke, and many others, both in hydrostatics and pneumatics, had fully demonstrated the fallacy of the Cartesian notion of a *plenum*, or the theory which supposed that all space is filled with matter, either in a solid or fluid state. But it remained for the illustrious Newton, and other celebrated mathematicians of that age, to furnish a scientific refutation of the popular theory by their profound investigations into the nature and properties of fluids, both elastic and non-elastic. A valuable portion of the " Principia" of Sir Isaac Newton treats of the *resistance* and *compressibility* of fluids, and the general laws by which their motions are regulated. The design of this part of his philosophical writings, is to apply the

great principles of dynamics to fluid, in common with solid bodies, and shew that the same effects are produced in both cases by the composition of forces. On this subject he first demonstrates, that the resistance which solid bodies moving in fluids encounter, gradually increases in proportion to the space they occupy, the velocity with which they move, and the time they have been in motion. Thence he proceeds to investigate their different degrees of density; the causes of resistance arising either from the *vis inertiæ* of matter, or the tenacity of fluid particles, or the friction of solids moving in them or floating on their surface; and also the velocities with which they move in all possible cases. From these researches into the laws of motion, as applied to incompressible fluids, this great philosopher proceeds to investigate the phænomena of those which are elastic, and estimates the degree of resistance encountered from this cause. He demonstrates that the measure of that resistance will be in exact proportion to the density of the body, and the density of the fluid, on each of which the repelling force of the elastic fluid will depend. The last object of investigation in this department of philosophy, relates to the effect produced by the different configuration of bodies moving in fluids; an inquiry of immense importance to the art of navigation, as well as applicable to many other mechanical processes.

IV.

OPTICS.

SECTION I.

ON THE PROGRESS OF OPTICAL SCIENCE DURING THE SIXTEENTH CENTURY.

315. THE history of Optics has been already sketched in its earlier stages. The visionary theories of Plato, the practical science of Archimedes, the progressive discoveries of Ptolemy, Alhazen, Roger Bacon, and Vitello, have been cursorily noticed in former divisions of this work.* But all the inventions and improvements of preceding ages, in connexion with this department of science, are as nothing compared with those which are now to be related. When this is asserted, no reflection is intended on the ancients. They achieved great things with their slender means and imperfect instruments of observation. The brilliant discoveries of modern times are chiefly attributable to the almost fortuitous invention of instruments of great power, unknown to the philosophers of former ages, and without which those discoveries could not possibly have been made. The modern history of this science (as far as it is intended to be pursued in this elementary volume) may be conveniently

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* Vide § 106, 107, 111, 211, 225.

divided into three parts; the first, including the progress made before the invention of the telescope —the second, extending from that memorable æra to the time of Newton—and the third, comprehending the optical discoveries of that great philosopher himself.

316. At the commencement of the sixteenth century two individuals flourished, who have acquired an honourable distinction among the earliest promoters of optical science. These were MAUROLYCUS of Messina, and BAPTISTA PORTA of Naples. Maurolycus was, as already stated, a profound mathematician, who brought his geometrical science to bear with great effect on his optical investigations. Baptista Porta was an experimentalist, who owed his most valuable discoveries to the careful observation of the phænomena of nature.

MAUROLYCUS chiefly directed his researches, in this branch of physical science, to the laws of refraction as they affect the visual organ—to the structure and mechanism of the human eye—to some of the properties of light—and to the nature and causes of the rainbow. He was the author of two treatises on the general theory of optics; one entitled, "*Theoremata Lucis et Umbræ;*" the other, "*Diaphanorum Partes,*" &c.; both of which contain curious and highly interesting researches into the phænomena of light, whether refracted or reflected. These, though frequently erroneous, unquestionably prepared the way for future discoveries, and, by doing this, rendered a valuable service to posterity. The most important of the optical discoveries of Maurolycus (if, indeed, they were his), relate to the theory of vision, as developed by the structure of the human eye. He is said to have first demonstrated, that the crystalline humour of the eye is a lens, that collects the rays of light issuing or reflected from external objects into a focus, by which means they are rendered visible: and also to have assigned as a reason for more or less distinct vision, the greater or less convexity of this crystalline lens. Another curious discovery attributed to Maurolycus is, a solution of the true cause of the circular appearance of the sun, though its rays are transmitted into a dark room through angular apertures. To the preceding may be added, his observations on the rainbow, in which his profound mathematical science was successfully applied to the measurement of the interior and exterior arches, and the spaces between them.

317. **Baptista Porta** is chiefly celebrated as the inventor of the *camera obscura;* the first announcement of which was made in a celebrated work entitled, "*Magia Naturalis.*" This book greatly alarmed the papal hierarchy, and was denounced at its first publication as heretical; but it contained such a mass of curious and valuable information on all subjects connected with the science of optics, that it speedily obtained a rapid and almost universal circulation. It was translated into the Italian, French, Spanish, German, and Arabic languages; and great multitudes of persons from distant parts of Europe repaired to Naples to obtain further information respecting the optical illusions which

it developed. The description given in this work of the camera obscura is extremely brief, and constituted a very subordinate object of attention. It is almost incidentally mentioned; for he merely states (among other curious facts), that "if a small hole be made in the shutter of a window, all external objects will be visible, in their proper colours, on the opposite wall; and farther, that if a convex lens be placed in the aperture, the images in the focus of that line will be rendered much more distinct; so distinct, that even the features of persons out of the room may be distinguished by those within." Yet this simple discovery, thus unostentatiously announced, has rendered the name of its inventor celebrated in the annals of science. B. Porta does not appear to have been acquainted with the experiments of Maurolycus on the human eye, but pursued independently a similar train of investigation, and arrived nearly at the same results, as is evident from his assertion in a part of his Magia Naturalis, that the eye is a natural *camera obscura;* an assertion, the correctness of which has been abundantly demonstrated.

318. But notwithstanding the advances made by the two above-mentioned philosophers, towards a correct knowledge of the theory of vision, neither Maurolycus nor his ingenious contemporary fully understood the process by which objects become visible. Both appear to have imagined that the pupil of the eye, and not the retina, is chiefly concerned in this phænomenon. The illustrious Kepler, who first developed the true laws of planetary

motion, supplied also this important link in the chain of optical science. Following up the train of discovery commenced by Porta and others, he analysed carefully the entire process of nature in the structure of the eye, and the adaptation of its several parts to the perception of objects. He proved that the images of external objects are painted on the retina; explained the cause of their inverted appearances, and solved the problem, why objects thus inverted on the retina, appear to the observer in their natural position; measured the angles of divergence or convergence under which they are seen, and proceeded far towards the development of the laws of refraction. The results of these important investigations are contained in his treatise on "*Dioptrics*." Nor was Kepler the only scientific philosopher of that age, who illustrated this interesting branch of optical science. Antonio De Dominis, Scheiner, Snellius, Des Cartes, and Kircher, all contributed, in various degrees, to its advancement.

319. ANTONIO DE DOMINIS, Bishop of Spalatro, made some important discoveries in the theory of refraction, in consequence of his diligent and minute observation of the phænomena of the rainbow. Though many philosophers of higher reputation and much greater science had directed their attention to the remarkable appearance of the Iris, all had failed to discover its true cause. De Dominis perceived, that it is occasioned by a double refraction and one reflection, and illustrated the fact by a familiar experiment. "Having placed a bottle of

water opposite to the sun, and a little above his eye, he saw a beam of light issuing from the underside of the bottle, which exhibited different colours in the same order, and with the same brilliancy, as those of the rainbow. On a more attentive observation, he found that the solar ray had been refracted on entering the bottle, and again at leaving it; and that it had been reflected from the concave part, so as to fall upon the eye, tinged with different colours; but why those colours appeared, and why invariably in a certain order, neither he, nor any philosopher who succeeded him, could explain, till the discoveries of Sir Isaac Newton, on the refrangibility of light, solved the mystery. The experiments of De Dominis on the rainbow were first published in his treatise, "De Radiis Visus et Lucis," about A. D. 1611. It is to be regretted, that the court of Rome, which has so often proved itself hostile to the advancement of science and truth, interposed its authority to check the Archbishop of Spalatro in his scientific career; compelled him first to take refuge in England, and subsequently, having enticed him back to Rome, shut him up in the castle of St. Angelo, where he is supposed to have been secretly poisoned, about A. D. 1625.

320. SNELLIUS, the celebrated Dutch mathematician, is acknowledged to have first discovered the great fundamental law of refraction, after Kepler, Tycho Brahe, Des Cartes, and Kircher, with many others of inferior name, had in vain attempted to ascertain its cause; and the probable reason of his success and of their failure was, that he relied

wholly on experiments, while the great philosophers just enumerated depended in part on *à priori* reasonings and hypotheses. By a great variety of delicate and accurate experiments, Snellius not only proved that light is variously refracted in passing through different media, and that in proportion to their density; but also discovered the reciprocal relations which the incident and refracted rays bear to their vertical or perpendicular line. Des Cartes, in some of his later writings, states this principle more clearly, by laying it down as a general fact, "that the sine of the angle of incidence always has the same ratio to the sine of the angle of refraction." This is announced as his own discovery; but sufficient evidence exists that Hortensius, a friend of Snellius, had, in his public lectures on optics, announced and explained this law of refraction before the date of Des Cartes' treatise on "Dioptrics," and had publicly ascribed it to his illustrious friend.

321. **Scheiner**, who flourished towards the close of the sixteenth century, directed his optical researches chiefly to the laws of vision, by analyzing the eye, discovering the humours and teguments of which it is composed, and observing the manner in which they cooperate to produce the result. Among other curious optical discoveries, attributed to this accurate experimentalist, are those of the contraction and dilatation of the pupil of the eye, as the object is nearer or further distant, or as the light falling upon it is more or less vivid; the reason why objects appear single, though seen with two

eyes; and the causes of some familiar optical illusions, which every one must have perceived, but which philosophy alone can explain. The same remarks will apply to those parts of Des Cartes' writings, which relate to the theory of vision, and are of most value, because resulting from experiment rather than theory. But on other questions connected with the science of optics, particularly those which relate to the nature and properties of light, this great philosopher was misled partly by his attachment to ancient systems, but chiefly by his preconceived notions of a *plenum* throughout the universe. On the ground of this false hypothesis, (for such it has been fully proved to be,) he maintained the instantaneous transmission of light from the remotest objects to the eye of the observer,—a doctrine, the fallacy of which was demonstrated by Roëmer's discovery of the velocity of light alluded to in a former section. (§ 284.)

322. To include, in the present section, all the most important discoveries which relate to dioptrics, though it lead us somewhat beyond the date of the first discovery of the telescope, it may be stated in this place, that at the commencement of the seventeenth century, some valuable experiments were made at Rome by Kircher on the doctrine of colours, and the manner in which they are produced by rays falling at different angles; but ingenious as they were, and some approaching towards the truth, they were necessarily erroneous, since the great cause of the phænomena of colours still remained unknown.

SECTION II.

HISTORY OF OPTICS CONTINUED,

From A. D. 1600 *to* 1650.

323. THE train of optical discoveries alluded to in the last section, belong not exclusively to the sixteenth century, nor were they all made prior to the period about to be reviewed. The chronological order of scientific discoveries has been somewhat inverted, that the history of the *telescope* and *microscope*, two of the most important inventions of modern science, might be presented in a more entire and connected form. The æra of these inventions is of the utmost importance in the history of mankind, since they are amongst the most remarkable in themselves, and most beneficial in their consequences, of all the productions of human genius. They have enlarged the boundaries of human vision to a degree which would previously have been deemed incredible; they have subjected to philosophical investigation the minutest as well as the most stupendous of natural objects; or, to employ the language of a distinguished modern writer, "by these discoveries, man has approached the nearest to the construction of a new organ of sense." Not curiosity alone, but a sense of justice to the benefactors of their species, naturally prompts the inquiry to which the present section is intended to furnish a brief reply, "to whom are we indebted for these inventions, and through what successive stages

of improvement did they pass, in the earlier period of their history?"

324. It has often occurred, that some of the happiest discoveries of the human mind are attributable to accident rather than design; and that the first conception was so vague and imperfect as to render it difficult to trace out its true origin. This remark will apply to the invention of the telescope in a greater degree, perhaps, than to any other of equal magnitude. The date of this important discovery is clearly ascertained to have been the commencement of the seventeenth century; but the original inventor is still a question of uncertainty. The celebrated astronomer Galileo, who first pointed the telescope to the heavens, and discovered there what the eye of man had never before seen, has been considered by some its inventor; and if, by the term invention, is meant, not the mere mechanical construction of the instrument, but the development of its scientific properties and use, the honour unquestionably belongs to Galileo. But it may be gathered from the writings of this philosopher, that the first intimation of such a discovery having been made in a distant part of Europe, and by some obscure mechanic, was given him by a learned friend; which led him to apply his mathematical science and mechanic skill to the construction of a similar instrument. The use of lenses, to assist the sight and magnify the objects of vision, was not wholly unknown to the ancients. It is manifest, from the *Opus Majus*, that Roger Bacon had employed convex lenses of different powers for this purpose. But

at length, some humble individual, "alike to fortune and to fame unknown," hit upon the idea of looking through two of these glasses at once—the one convex, and the other concave—fixed at either extremity of a tube; and thus constructed the first rude and imperfect telescope. Des Cartes, who flourished at the time of this noble discovery, and took some pains to investigate its origin, attributes it to *Metius*, an optician, resident at Alcmaër, in Holland; but the more prevalent opinion is, that Zechariah *Jans*, or *Jansen*, an ingenious but humble mechanic of Middleburgh, in Zealand, was the original inventor of this important instrument. Such at least is the statement of Borellus, who, within a few years from the date of the discovery, seems to have investigated the question with great care and impartiality.*

325. Galileo's telescope consisted but of two lenses—a convex and a concave—the former of which being fixed at the end of the telescope, caused the parallel rays of light falling upon it to converge towards a focus; but before they arrived at the point of convergence, the concave lens was interposed, by which their direction was changed, and they again became parallel; thus presenting a distinct but enlarged image of the object at the focus of parallel rays, at which point the eye of the observer must be placed. All that was effected, therefore, by this telescope was, to exhibit the object under a much larger angle than its ordinary or natural appearance. This telescope did not exhibit objects in an inverted position, because the rays of light, by this simple but powerful instrument, cross each other only at one point. One great inconvenience, however, attended this instrument; the field of vision was extremely limited, and that in proportion to the increase of its magnifying powers ; an inconvenience which has been felt so strongly by modern astronomers, that they have frequently expressed their surprise at the numerous and wonderful discoveries Galileo was enabled to make by its means.

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* For a detailed account of the origin of the telescope, and discussion of the respective claims of Metius, Jans, Lipperstein, and others;—refer to Montucla's or Bossut's History of Mathematics—Smith and Priestley "on Optics"—or to the article *Optics* in Encyc. Britt.

326. The next stage of improvement in the history of the telescope quickly followed its discovery, which was suggested, but not executed, by the great Kepler, in honour of whom it is usually designated, the *astronomical*, or *Kepler's* telescope. It chiefly differs from that of Galileo, by being constructed with two convex lenses, instead of a convex and concave; the effect of which is, that objects are inverted, but they are also greatly magnified, they are more distinctly seen, and the field of vision is enlarged.

Kepler was either not aware of the importance of the improvement which he had suggested, or his attention was drawn from it to other investigations. Certain it is, that Scheiner, availing himself of the instructions given by Kepler, after the death of that great philosopher, constructed the first astronomical telescope, so called because of its peculiar adaptation to the survey of the heavenly bodies. But a yet more valuable service was rendered by Kepler with reference to the telescope. It was he who first explained the *rationale* of this important instrument, by developing the power of different lenses, and the general laws of parallel, converging and diverging rays of light; together with the effects produced by changing the position or increasing the number of magnifying glasses.

327. Hitherto the only species of telescopes which had been invented, was the *dioptric,* or that which depended alone on the refrangibility of light. In these, several improvements of minor importance were made at different periods, particularly by Scheiner, Huygens, Rheita, Campani, and Hooke. But at length a more important improvement was given to this instrument, by employing the combined influence of refraction and reflection. The first idea of a *reflecting* telescope is attributed to *James Gregory,* of Aberdeen, whom Playfair characterises as "a profound and inventive geometer, who wholly devoted himself to the study of optics. In a celebrated treatise, entitled '*Optica Promota,*' this scientific philosopher discussed many questions relative to the force of lenses of various kinds; suggested valuable hints respecting the means of correcting the indistinctness of vision generally complained of in refracting telescopes, and described the reflecting telescope recently invented by himself. He was led to this invention, in consequence of the great inconvenience found in the employment of spherical lenses, and the extreme difficulty of freeing

them in so great a degree from the prismatic colours, as to discern objects distinctly and closely. He determined, therefore, to construct a telescope into which metallic specula, or highly polished mirrors, should be introduced instead of lenses. This contrivance was peculiarly happy, not only as in itself valuable, (since it obviated the two principal objections to refracting telescopes, namely, their great length, and their indistinctness of vision,) but still more as having led to the most important invention of the *reflecting telescope* by the illustrious SIR ISAAC NEWTON.

328. The invention of the microscope quickly followed that of the telescope—an instrument, which (to adopt the emphatic language of Professor Playfair on the subject) " discovers an immensity on the one side of man—scarcely less wonderful than that which the telescope discovers on the other. The extension and divisibility of matter are thus rendered to the natural philosopher almost as unlimited as the extension and durability of space are to the geometer.*"

In this, as in the former case, the question of origination has been contested; some ascribing the invention to Galileo; some to Jansen and his son, the inventors of the telescope; and some to Cornelius Dobrell, a native of Alcmaër. Without presuming to settle this dispute, it will be sufficient to remark, that the true date of the invention is about A. D. 1618; and that the instrument was first constructed in the simplest manner. It consisted but of a very convex lens, interposed between the eye and the object; the effect of which is, by shortening the focus, to exhibit the object under a greater angle, and thus proportionably to increase its apparent diameter. The first great improvement suggested in this instrument, was that of the *compound* or *double miscroscope,* which corresponds with the astronomical telescope, since it consists of two convex lenses, an object and an eye glass; the former of which magnifies the object, and the latter brings it nearer to the eye. The precise æra, and the inventor of this improvement of the microscope, are not certainly known; though it is ascertained to have quickly followed the original discovery. Many valuable experiments in physical science were made, by means of this admirable instrument, soon after its invention, by the indefatigable *Huygens,* the excellent *Boyle,* and, above all, the celebrated *Leuwenhoek,* whose microscopical discoveries were so numerous and great as almost to exceed credibility.

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* Vide Playfair's Second Diss. ut sup. p. 120.

SECT. III.

HISTORY OF OPTICS CONTINUED,

From A. D. 1650 *to* 1700.

329. THE facilities afforded to scientific men employed in optical researches, by the ever-memorable inventions of the telescope and microscope, were so great, that almost every distinguished philosopher of that age was induced to direct his attention to this interesting department of science. Scarcely is there

an individual, whose name has been introduced in connexion with other divisions of natural philosophy, who might not also be included among those who contributed, in a greater or less degree, to the advancement of optical science. It would be easy to multiply names and facts in proof of this assertion; but, as in former portions of this work, so especially in the present, it is requisite to proceed on the principle of *selection.*

330. The indefatigable HUYGENS first claims attention, who entered with all the ardour of youth into this study, happily combining a high degree of scientific with practical knowledge. His treatise on " Dioptrics," of which Newton speaks in terms of high commendation, was among the earliest productions of his pen. In this work he not only develops the principles of optics in general, but applies those principles to practical purposes, by investigating the causes of the indistinctness of refracting telescopes, and suggesting rules for their improved construction, which were the results of his own experience; for he had himself polished lenses of high magnifying powers and extraordinary clearness of vision. In 1678, he communicated to the Academy of Sciences, at Paris, a valuable treatise on " the Nature and Properties of Light, the Laws of Refraction and Reflection," and many other topics connected with the science of optics. These celebrated works were succeeded, at different periods, by highly scientific papers on similar subjects; particularly on the phænomena of coronæ, parhelia, and paraselenes; several of which are minutely described from his own attentive observation, and their causes satisfactorily explained.

331. GRIMALDI, a distinguished member of the Academy Del Cimento, who flourished about the middle of the seventeenth century, is chiefly celebrated, in connexion with optical science, by his discovery of a property of light which had escaped the observation of all previous philosophers; to which was primarily given the name of *diffraction*, but which, since the time of Newton, has generally been designated the *inflection* of light. This term expresses that motion of rays of light which is perceived when they approach within a small distance of another body, and which, instead of proceeding, according to the laws of optics, in a right line, are *deflected*, or caused to bend either towards or from the object, thus producing a kind of imperfect reflection or refraction. The first public announcement of this discovery was made by Grimaldi, A. D. 1666, in a treatise on "Light, Colours, and the Rainbow." About six years after, the same discovery was communicated to the Royal Society, by Dr. Hooke, as the result of his own observations, and apparently without any consciousness of its having been previously known. In the papers of this great astronomer on the subject, published in the "Philosophical Transactions" of that period, a circumstantial account is given of the phænomenon itself, and the process by which he was led to the discovery. The observations, however, of Grimaldi, are incomparably more correct and philosophical; and are of themselves sufficient to confer lustre on the name

and memory of their inventor. In other respects, it is readily admitted, that Hooke contributed in a high degree to the advancement of optical science—particularly by his experiments on refracted and reflected light — his improvement of the telescope—his elucidation of the theory of vision, and his development of the doctrine of colours, as far as it was then understood.

332. The organ of sight is a faculty so mysterious, and yet so important, that it must ever form an interesting object of research to scientific men. Many were the individuals, who vied with each other in their endeavours to explain the phænomena of vision, at the period to which the present section refers. Among these may be enumerated, of our own countrymen, Boyle and Barrow; and among foreign philosophers, De la Hire, Mariotte, and Leibnitz.

(1.) The pious and excellent Boyle, whose life was devoted to the advancement of experimental philosophy in all its several branches, directed his chief attention to that division of optical science, which relates to colours, their principles and causes, and the constitution of bodies on which they depend. The results of his elaborate investigations on this subject are given in one of his earliest productions, entitled, " Experiments and Observations on Colours," published about A. D. 1663.

(2.) Dr. Isaac Barrow, who must be classed with the most profound philosophers of modern times, investigated the laws of refraction, as applied to the phænomena of vision. This subject formed a principal and most valuable part of his "optical lectures," first delivered in the university of Cambridge, and subsequently published, about A. D. 1674, in which profound mathematical science was combined with a high degree of practical and experimental knowledge.

(3.) M. De la Hire, a distinguished French philosopher, who flourished about the same period, pursued a similar train of investigation. In conjunction with his fellow-countryman, Mariotte, he took an active part in the controversy, which was then carried on respecting the seat of vision, and the manner in which external objects become visible. The questions chiefly related to the part of the eye on which the image is impressed—the effect produced by rays of light on the optic nerve — and the mysterious *nexus* between impressions made on the organ of sight, and the internal perception of the object. On all these and many other subjects connected with the phænomena of vision, this acute observer of nature communicated much valuable information—the result, not of theory, but of patient and accurate experiment.

(4.) Mariotte, who was the principal cause of exciting the controversy alluded to above, respecting the seat of vision, was the first who demonstrated, what had been conjectured by Des Cartes and others, that objects are seen, not in the crystalline humour of the eye, but through its medium; and that the true seat of vision is to be sought in the optic nerve attached to the *choroidal* membrane, or, as others maintained, to the *retina*.

(5.) Leibnitz was too ardently devoted to science to permit, that investigations so curious and profound should be carried on, without directing to them the energies of his powerful mind. Several valuable papers were published by him in the Leipsic Transactions for 1682, on the principles of "*Optics, Catoptrics,* and *Dioptrics*;" in which much light is thrown on the previously established laws of refraction and reflection, and many valuable additions were made to the science. All these, however, and every other optical discovery of this *Augustan age* of science, were completely eclipsed by the brilliancy of the development made by our illustrious fellow-countryman, Sir Isaac Newton, a summary of which will be presented in the next section.

SECT. IV.

ON THE OPTICAL DISCOVERIES OF SIR ISAAC NEWTON.

333. ANOTHER highly interesting train of physical discoveries remains to be noticed; which are not less surprising than those to which we have alluded in former sections, and in connexion with other departments of philosophy. The state of science in general, and especially of optical science, when NEWTON commenced his philosophical career, was such as could not fail to enkindle his enthusiasm, and stimulate to patient and persevering exertion. The properties of light, and the theory of vision, had

been in part developed—the laws of reflection and refraction had been demonstrated, both scientifically and practically—a new and almost boundless field of science had been laid open, by means of convex and concave lenses variously combined—but yet there remained much to be investigated and known. The phænomena were familiar to men of science, but their causes were as yet unknown. "What is the true nature of that transparent fluid, called *light*—and why, under certain circumstances, is it variously refracted or reflected?"—these, with many similar inquiries, which would naturally suggest themselves to the mind of a philosophical observer of nature, were subjects still veiled in mystery and darkness; till Newton arose, who, instead of theorizing and speculating on the subject, had recourse to the most patient, minute, and oft-repeated experiments, until he at length succeeded "in untwisting the splendid robe of day."

334. Newton was little more than twenty-three years of age when he commenced these profound researches into the nature and properties of light, which led to a long train of curious and sublime discoveries. It is probable that his attention was first directed to this subject by the celebrated work of Huygens, alluded to in the last section; in which that great practical philosopher had developed a new theory of light, that appeared to him satisfactorily to explain the phænomena and laws of refraction and reflection. According to Huygens, "Light consists in certain undulations, communicated by luminous bodies to the ethereal fluid which

fills all space. This fluid is composed of the most subtile matter, is highly elastic, and the undulations are propagated through it with great velocity in spherical superficies proceeding from a centre." The treatise in which this ingenious theory was developed and defended, appears to have first attracted the attention of Sir Isaac Newton to optical researches. A circumstance, apparently accidental, greatly facilitated his investigations. When trying the effect of lenses of different forms, with the hope of improving the telescope, by rendering the field of vision more distinct, he hit upon the *prism ;* and his sagacious mind quickly perceived that the instrument was well adapted to the investigation of the causes of the primary colours. These he discovered and fully demonstrated to be produced by the *different refrangibility of different rays of light ;* those which are least refrangible producing the darker and stronger colours, such as red, orange, and yellow; while those which are most easily refracted, being weaker rays, produce the fainter colours of violet, blue, &c. Not satisfied with the experimental proof of this fact, obtained by an attentive observation of actual phænomena, this profound philosopher proceeded to the decomposition and re-union of solar rays under all possible circumstances, in order to shew the precise quantum of the refrangibility of each, and the order in which they are severally combined. Applying these facts to the rainbow, he gathered thence the most convincing demonstrations of his hypothesis, relative to the cause of the prismatic colours. To him belongs the honour of having proved beyond all doubt, that the Iris is but a magnificent prism produced by natural causes; since, in comparing its colours with those exhibited by the prism, it was found that they are precisely the same, and in the same order. "Newton showed," says Playfair, "the truth of his principles by calculating the extent of the arch described in the heavens—the breadth of the coloured bow—the position of the secondary bow—its distance from the primary—and by explaining the inversion of colours. There is not perhaps in the whole range of science, any instance of happier application of theory, or one in which the mind rests with fuller confidence."*

335. There remained, however, another interesting object of investigation, with reference to the doctrine of colours, which did not escape the penetration of Newton. It had been proved, that what might appear to be a single solar ray, was, in reality, a pencil of rays, capable of being decomposed by the prism, and exhibiting different colours; but it was not yet ascertained why objects appeared uniformly of the same colour; one red, a second blue, and a third green, &c. This was shewn, by the experiments of our great philosopher, to be occasioned by the greater disposition of a natural substance to reflect rays of one colour, than those of another which fall upon it. Thus the far greater number of leaves have a tendency to absorb the red, yellow, or blue rays, and to reflect the green; for which reason, they exhibit the latter colour to the

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* Playfair's Second Diss. p. 49.

eye of the observer. On investigating the subject more deeply, he perceived the combined influence of the two great properties of light, reflection and refraction, in the production of the phænomena of colours. Refraction decomposes the solar ray, and separates those which are less from others which are more refrangible; while the laws of reflection determine the manner in which they will severally fall on the eye, and, consequently, what colour an object will assume in any given position. The most curious, but perhaps the most vulnerable part of Newton's theory on this question, relates to what he terms "fits of easy transmission or reflection; a theory which, whether completely satisfactory or not, certainly solves many otherwise inexplicable phænomena.

336. The next important step in this series of optical discoveries, relates to the manner in which light is propagated, and the inferences deduced from its mode of transmission, serving to illustrate more fully its nature and properties. The fact was established, by innumerable experiments, that light is an emanation of particles inconceivably subtile and minute, moving in right lines with incredible velocity, and attracted by the particles of transparent bodies. Applying the principles of dynamics (as far as they relate to the laws of motion) to this theory, he found that they mutually illustrated and established each other. The doctrine of *vibrations,* according to the Cartesian hypothesis, and that of *undulations,* maintained by Huygens, was effectually exploded; and demonstrative evidence

was given, that rays of light, whether descending perpendicularly, obliquely, or in any other direction, were subjected to all the laws common to falling bodies under such circumstances. From this fact many important consequences were deduced. A new light was poured on scientific philosophy. Chemists were furnished with new data on which to proceed in their analyses, and by which they may be led on to further discoveries. When these results of patient and profound investigation into the nature of light, and the manner in which it is propagated, were communicated to the scientific world through the medium of the "Philosophical Transactions," the utmost astonishment was excited; some doubted their truth; others denied the consequences deduced from them; but all were enthusiastic in their admiration of the young English philosopher, whose patience of research was equal to the fertility of his invention and the depth of his science.

337. Among the most useful results of Newton's optical experiments on light, the improvement of the telescope, which was by this means suggested to his sagacious mind, was not the least. It had long been found that the indistinctness with which objects were seen through refracting telescopes of high magnifying powers, operated as a great check to astronomical discoveries. The most eminent mechanicians of Europe, (among whom were Eustachio Divini of Rome, and Campani of Bologna,) had exerted their utmost skill to remedy this inconvenience with little success. They had enlarged the diameter of their lenses, and heightened their polish, and tried various kinds of curves; but still the difficulty remained to be overcome. The fact was, none of the philosophers who preceded Newton had ascertained the true cause of the indistinctness complained of, and of course were not likely to suggest a remedy. But Sir Isaac Newton's discoveries, with respect to the refrangibility of light and the prismatic colours, at once solved the mystery. Rightly judging that the principal cause of the evil was the unequal refrangibility of the component parts of the solar rays, he concluded, that the object desired might be more easily obtained by reflection than by refraction. To verify this conjecture, he polished with his own hand the first metallic speculum, and constructed a reflecting telescope, the utility of which seems to have far exceeded his expectations. This important instrument was completed in 1671; and in the following year, a letter addressed to Oldenburg, the Secretary of the Royal Society, appears in the Philosophical Transactions, communicating the first intelligence of the success of his experiments, and giving an accurate description of his new optical machine. This reflecting telescope of Sir Isaac Newton differs so essentially from those previously alluded to, as constructed by James Gregory, and improved by Dr. Hooke, that it may justly be accounted a new and original invention.

338. The last in this unparalleled series of brilliant discoveries, which it is requisite distinctly to notice, relates to the experiments of this profound philosopher on the *inflection* or *reflection* of light.

The original discovery of this property of light had been made a few years before by Grimaldi (§ 331.); it appears to have been re-discovered, about six years after, by Hooke; but it was not understood, it was not clearly defined—it can scarcely be said to have been proved to exist—till the various and minute experiments of Newton placed it beyond doubt, and fully ascertained the cause of the phænomenon. From this, as from a thousand other sources, were drawn additional proofs of the great law of gravitation. Towards the close of his admirable work on optics, a series of valuable hints were submitted to the learned world in the form of *queries*, either because they had not yet been sufficiently verified by experiment, or because they were merely the conjectures of his penetrating mind: but to intellects like those of Bacon, Newton, and a few other highly gifted individuals, conjectures and anticipations almost partake of the character of predicted discoveries. Each revolving year, and every additional fact, have served but to verify the truth of many of these conjectures, and heighten our admiration of the profound genius which gave them birth.*

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* Many valuable papers, containing full information of these stupendous discoveries, appear in a scattered form in the earlier volumes of the Philosophical Transactions; part of these have been subsequently collected and published among his philosophical works. Besides which, he wrote on the subject "Lectiones Opticæ," or Lectures on Optics, delivered at Cambridge, and a treatise on Optics, in three books.

SECTION V.

SKETCH OF THE HISTORY OF EXPERIMENTAL SCIENCE DURING THE SEVENTEENTH CENTURY.

339. THE term experimental philosophy, may be applied in its extended signification to all the departments of physical science, as far as they depend on observation and experience. Few of the memorable discoveries in natural philosophy, which have been noticed in the preceding sections, could have been made without the aid of patient analysis and unwearied diligence of research. Galileo, Huygens, Leibnitz, and Newton, may therefore be justly accounted experimental, as well as scientific philosophers; nor is it less requisite to adhere strictly to this mode of investigation in astronomical, mechanical, or optical researches, than in those which relate to the constitution and transmutation of material substances. But at present, the phrase experimental science is used in a restricted sense, to denote those branches of natural philosophy which wholly depend on experimental proofs, and the evidence of facts; those which investigate the elementary principles of bodies, and their mutual agencies; those which develop the changes of which they are susceptible, the new properties they acquire, and the various phænomena they exhibit, in different states of combination or solution. These sciences have greatly multiplied in modern times, or rather have been subdivided, as practical knowledge has

increased; but at the period to which the present retrospect refers, none were known but *chemistry* and *electricity;* and these were as yet but in their infancy, compared with the vigour and expansion to which they have subsequently attained.

340. In a former part of this work, a transient allusion was made to the probable origin of *chemical* science among the Egyptians. (§ 53.) The indefatigable labours of the Arabian and European alchemists to procure the elixir of life, or to produce the philosopher's stone, have also been noticed. (§ 212, 226.) But these visionary pursuits can scarcely deserve the name of experimental science. Some useful discoveries were made, it is true, by a kind of felicitous accident, and some inconsiderable advances in practical knowledge resulted from them. But if this absurd mode of philosophizing had continued to the present day;—if men, pretending to science, had still endeavoured to controul, rather than investigate nature; to establish facts by hypotheses, instead of establishing hypotheses by facts; to subjugate the phænomena of nature to their theories, instead of deducing their theories from physical phænomena;—science had still remained stationary, nor should we have witnessed any of those bold and rapid flights which have been subsequently taken. To the profound and penetrating genius of the illustrious Bacon, it is attributed that the illusions of former ages were effectually scattered, and a flood of light was poured on even the most mysterious operations of nature. To him belongs the distinguished honour of having thrown down the bulwarks of ignorance and error; and pointed out the true path of science to all succeeding generations.

341. After the death of Lord Bacon, many of the philosophers of Europe, pursuing the track which he had distinctly pointed out in his "Instauration of the Sciences," entered with zeal and industry upon a course of experimental inquiry, the results of which were extremely important. Among those of our own countrymen, who thus distinguished themselves in the chemical department, were *Boyle, Hooke, Newton, Mayow,* and *Hales;* of the continental philosophers, the most successful in their experimental researches were, *Glauber,* of Amsterdam; *Brandt,* of Berlin; the Elder *Lemery,* of Paris; *Beccher,* of Spires; *Ernest Stahl,* of Anspach; and *Boerhaave,* of Leyden. The philosophical writings of BOYLE afford sufficient evidence of the industry and perseverance with which he investigated natural phænomena; but it has been justly remarked by a modern scientific writer, that his merit consists rather "in the indirect benefits conferred on science, by enkindling the zeal and directing the inquiries of others, than in the discoveries actually made by himself. HOOKE owes much of his celebrity and success, as an experimentalist, to the patronage of his noble friend and coadjutor, who first brought him into public notice, and furnished him with the means of pursuing his physical researches. The results of their united labours in pneumatic chemistry, and other departments of the science, are contained in two treatises published by Dr. Hooke, the first entitled, *Micrographia,* which appeared

in 1664, and the latter *Lampas*, printed in 1677. In these scientific works, many new and important experiments were announced, and not a few of the discoveries of future years were anticipated and partly developed. Though the mighty genius of *Newton* was chiefly applied to the mechanical operations of nature, he was not regardless of its internal phænomena. " To him," says a modern historian, " chemistry is indebted for the first correct views respecting the nature of combination; a subject which had little engaged the attention of the more sensible experimentalists of the preceding periods, and which was formerly attributed to the occult qualities of the Aristotelians, and afterwards to the mechanical forms of the particles of bodies." From this science, as well as from all the other branches of philosophy, this profound investigator of nature gathered proofs of the great law of attraction; for, to the same principle which puts in motion the vast machine of the universe, the chemical affinities and elective attractions are also to be attributed.*

342. The distinguished individuals alluded to in the last paragraph, were not chiefly indebted to chemical science for the posthumous fame they have enjoyed. They excelled, in many other departments of physical science, far more than in that of chemistry. But the practical philosophers about to be mentioned, were almost exclusively devoted to this species of physical investigations, and are only

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* Vide Brande's Diss. on the Progress of Chemical Philosophy, ap. Ency. Britt. N. Supp. Vol. III.

known to posterity in the character of theoretic or experimental chemists. Adhering still to Britain, we may first mention JOHN MAYOW, a native of Cornwall, who flourished about the middle of the seventeenth century, and was the author of several valuable chemical tracts, which continue to be highly esteemed. They principally treat of the nature of the atmosphere, the influence of fermentation on vegetable and animal substances, the cause of combustion, and the *nitro-aërial* spirit, with which the author conceived the atmosphere to be impregnated. "The entire collection of Mayow's tracts, published at Oxford, in 1674, relate to a great variety of chemical, physiological, and medical subjects, and abound in traits of original and inventive genius." They furnish the prototype of many modern discoveries, which have conferred great and lasting renown upon succeeding experimentalists.

Next in the order of time, among the English chemists, occurs Dr. STEPHEN HALES, a celebrated philosopher and divine, who flourished at the close of the seventeenth, and beginning of the eighteenth centuries. The attention of this great naturalist was principally directed to the nature and properties of air, in all its various states of combination, and the effects produced by different gases on animal, vegetable, or mineral substances. On this account he has been generally designated, the *founder of pneumatic chemistry*. "In perusing his Essays," says Brande, "we frequently find him on the verge of those splendid discoveries which fell to the lot of his fellow-labourers and successors; but the erroneous nature of his preconceived opinions induced him to take for granted that which experiment should have determined, and to rest satisfied with results which, had they been followed up, would have inevitably led to the most important and novel facts. His experiments do credit to his industry; but his conclusions betray feebleness of judgment."*

343. Among many experimental philosophers, who successfully pursued similar trains of physical investigation, in various parts of Europe, may be enumerated:

(1.) *Glauber* of Amsterdam, whose chemical works were first published at Frankfort in 1658, and contain an immense variety of curious and interesting facts. When the date of these publications, and the infant state of the science are considered, it cannot fail to excite surprise that so many curious discoveries should have been made so early; and that his experimental science should have taken so wide a range.

(2.) *Brandt* of Berlin, who discovered the inflammable substance, since denominated phosphorus, and described its properties, in several chemical tracts which appeared about A. D. 1669.

(3.) *Lemery* the elder, who delivered public lectures on chemistry at Paris, about A. D. 1674, with great applause, and whose celebrity chiefly rests on the attractive attire with which he invested his favourite science, in so much that his lectures, when published, were sought and read with the utmost avidity.

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* Vide Brande's Diss. ut sup. p. 26.

(4.) *Beccher* of Spires, a man of original genius and prodigious labour, of which his voluminous writings bear ample testimony. His principal and most curious works are entitled, *Physica Subterranea,* in which he treats of the original creation of matter, and the transition and interchange of the elements; and *Œdipus Chemicus,* or chemical institutions, which contains the history of the chemical elements, as far as they had then been ascertained, and the processes of the laboratory with regard to each.

(5.) *Ernest Stahl* of Anspach, in Franconia, flourished at the close of the seventeenth century, and is best known as the principal founder of the once celebrated, but now exploded system of *Phlogiston;* a system which rapidly spread through Europe, and acquired such universal credence, that it was with the greatest reluctance abandoned, even after its fallacy was brought to light. The chemical opinions of Stahl are chiefly detailed in his "Three Hundred Experiments," published at Berlin, A. D. 1731, and his "Fundamenta Chymiæ," which appeared soon after.

(6.) It is only requisite further to mention the celebrated *Boerhaave,* who, though born in the seventeenth century, did not acquire fame as an experimental philosopher, till the commencement of the eighteenth. At that time he was professor of chemistry, botany, and physic, in the university of

Leyden, on all which sciences he delivered public lectures, which were subsequently published, under the title of "Elements of Chemistry;" a work which has acquired great celebrity, and been translated from the original Latin into almost all the languages of Europe.

344. Having glanced at the progress of chemical science, and the individuals, both at home and abroad, who chiefly contributed to its advancement, it will be proper to advert for a moment to a kindred branch of experimental science, which began about the same period to attract attention — that of *Electricity*. This belongs exclusively to modern times; for, although some of the ancients observed the attracting power of amber, and occasionally allude to it in their writings as an occult quality of nature,* they had no conception of the nature or extent of electric attraction in general; and still less, of the remarkable phænomena resulting from its operation. The first who made any real advances towards the discovery of this science, was GILBERT of Colchester, who flourished about A. D. 1600, and was honoured with the appointment of physician to

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* Thales of Miletus first mentions it, and conjectured that the substance was animated. Theophrastus next alludes to it, about A. C. 300, and classes it among native fossils. Pliny, in his Natural History, speaks of the attracting quality of amber, though he makes no attempt to solve the mystery. Many later naturalists have also occasionally noticed this property, and described some of its effects, particularly Gassendi, Sir Kenelm Digby, and Sir Thomas Brown. — *Vide Priestley on Electricity*, pp. 1, 2.

Queen Elizabeth. He was the author of two highly philosophical treatises, entitled, "*De Mundo nostro Sublunari*," and "*De Magnete*." The latter of these contains a great variety of electrical experiments made on different substances. "To him," says Priestley, in his history of this science, "we owe a great augmentation of the list of electrical bodies, as also of the bodies on which electrics can act; and he has carefully noted several capital circumstances relating to the manner of their action, though his theory of electricity was very imperfect, as might be expected." After enumerating the several substances in which Gilbert discovered the property of electric attraction; and a sketch of his opinions as well as facts, the narrative is thus concluded:—"Such were the discoveries of our countryman Gilbert, who may justly be called *the father of modern electricity*; though it be true that he left his child in its very infancy." Some inconsiderable additions were made to the scientific discoveries of Gilbert, by Sir Francis Bacon, the detailed account of which will be found in his "Physiological Remains." The excellent Boyle carried somewhat farther these investigations, and made some discoveries, which may, in the present advanced state of the science, appear to be unimportant, but which at the time of their discovery were highly appreciated.

345. OTTO GUERICKÉ, the original inventor of the air-pump, was enabled, by means of that important instrument, eminently to promote the practical sciences in general. Many highly ingenious experi-

ments were made by him on electrified substances, and to him is attributed the first construction of a rude and imperfect electrical machine, which was nothing but a globe of sulphur mounted on an axis, and whirled in a wooden frame, rubbing it at the same time with his hand. By this simple contrivance he was enabled not only to perform all the experiments in electricity previously known, but also to make many new discoveries. Among the most important results of his persevering investigations in this department of science was, the demonstration of the fact, "that bodies immerged in electric atmospheres, are themselves electrified, and with an electricity opposite to that of the atmosphere." This experimental philosopher was also the first to discover the luminous appearances exhibited by the electric fluid, and the sound produced by electrical excitement.

346. Electricity was among the amusements, rather than the serious occupation of our great philosopher, SIR ISAAC NEWTON. Nothing that partook of the nature of science could be indifferent to him, nor was he regardless even of the minutest operations of nature. Though accustomed to soar, with untired wing, to the loftiest heights of finite intelligence, and include within the range of his profound investigation the entire mechanism of the universe, he did not account it beneath him to observe the movements of an electrified feather dancing on the table, or the attractive and repellent powers of magnetized and electrified substances in general. With that modesty for which this great philosopher has been so justly and eloquently eulogized, he proposed, in the form of queries, some valuable suggestions, the correctness of which subsequent discoveries have fully established and confirmed.*

SECTION VI.

GENERAL REMARKS ON THE PHILOSOPHY OF SIR ISAAC NEWTON.

347. THIS brief retrospect of the history of scientific philosophy will close with the memorable discoveries of Sir Isaac Newton, for reasons which have been assigned in the Preface to this work. But before we proceed to the remaining division, in which it is proposed to sketch the history of intellectual science from the revival of letters to the same period, it will not be irrelevant to introduce a few remarks on the general character and distinguishing feature of that new and sublime philosophy, of which he was the acknowledged founder. On many accounts, the æra of Newton must be accounted the most memorable in the history of mankind; and as such, it cannot be too attentively considered.

348. Many illustrious names occur in the list of his contemporaries and coadjutors, of which no other proof need be adduced, than to state that at the same period flourished Barrow and the

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* Vide Newton's Optics,--- Brande's Diss.---and Priestley on Electricity.

Bernoullis, Gassendi and Leibnitz, with a long train of other distinguished philosophers, who formed, by the pre-eminence of their genius and the brilliancy of their discoveries, a kind of intellectual galaxy, to which no other age can furnish a parallel. Yet Newton towers above them all, in the majesty of unrivalled genius, and appears like the sun in the midst of the celestial luminaries. "When we look back," says an eloquent divine and enlightened philosopher of the present day, "on the days of Newton, we annex a kind of mysterious greatness to him, who, by the pure force of his understanding, rose to such a gigantic elevation above the level of ordinary men—and the kings and warriors of other days sink into insignificance around him—and he at this moment stands forth to the public eye in a prouder array of glory than circles the memory of all the men of former generations; and while all the vulgar grandeur of other days is now mouldering in forgetfulness, the achievements of our great astronomer are still fresh in the veneration of his countrymen, and they carry him forward in the stream of time with a reputation ever gathering, and the triumphs of a distinction that will never die."*

349. The justly admired writer, from whose luminous pages the preceding extract has been taken, has sketched with a masterly hand the prominent features of the philosophy of Newton, and fully shewn that they chiefly consist in a rigid

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* Vide Dr. Chalmers' Discourses on the Christian Revelation viewed in Connexion with the Modern Astronomy. Disc. II. p. 60.

and inflexible adherence to evidence, and the utter absence of all theory and hypothesis. To this our great philosopher owes his most valuable discoveries, and by this he is honourably distinguished from the most illustrious of his predecessors and contemporaries. Des Cartes and Leibnitz, both of whom may justly be classed with the most highly gifted of their species, were given to theorize, and were not unfrequently betrayed, by their love of speculation, into philosophical errors and absurdities. The *vortices* of the former, and the *monads* of the latter, are striking illustrations of this fact. But Newton was proof against every such temptation; and the mighty fabric of philosophy, reared by him, remains unshaken and impregnable, because founded on the rock of experimental truth. "It was," adds the before-cited author, "the property of his mind, that it kept a tenacious hold of every position which had proof to substantiate it; but it forms a property equally characteristic, and which, in fact, gives its leading peculiarity to the whole spirit and style of his investigations, that he put a most determined exclusion on every one position that was destitute of such proof. He would not admit the astronomical theories," (and the same remark will apply to all his physical researches,) "of those who went before him, because they had no proof. He would not give in to their notions about the planets wheeling their rounds in whirlpools of ether, for he did not see the ether; he had no proof of its existence; and besides, even supposing it to exist, it would not have impressed on the heavenly bodies such movements as met his observation. He would not submit his judgment to the reigning systems of the day, for though they had *authority* to recommend them, they had no *proof;* and thus it is that he evinced the strength and soundness of his philosophy, as much by his decisions on those doctrines of science which he rejected, as by his demonstration of those doctrines of science which he was the first to propose, and which now stand out to the eye of posterity as the only monuments to the force and superiority of his understanding." (pp. 63, 64.)

350. The writer of these elements cannot forbear to decorate his pages with one other extract from this admirable discourse, and the rather as it may tend to throw additional light on some of the facts which have been related in former sections of this work. "In that march of intellect which led him (Newton) onwards through the rich and magnificent field of his discoveries, he pondered every step; and while he advanced with a firm and assured movement wherever the light of evidence carried him, he never suffered any glare of imagination or of prejudice to seduce him from his path. Sure I am, that in the prosecution of his wonderful career, he found himself on a way beset with temptation on every side of him. But he expatiated on a lofty region, where, in all the giddiness of success, he might have met with much to solicit his fancy, and tempt him to some devious speculation. Had he been like the majority of other men, he would have broken free from the fetters of a sober and chastised understanding, and, giving wing to his imagination, had done what philosophers have done after him—been carried away by

some meteor of their own forming, or found their amusement in some of their own intellectual pictures, or palmed some loose and confident plausibilities of their own upon the world. But Newton stood true to his principle, that he would take up with nothing which wanted evidence, and he kept by his demonstrations and his measurements and his proofs; and if it be true that 'he who ruleth his own spirit is greater than he who taketh a city,' there was won, in the solitude of his chamber, many a repeated victory over himself, which should give a brighter lustre to his name than all the conquests he has made on the field of discovery, or than all the splendour of his positive achievements." (pp. 66, 67.)

351. But though the philosophy of Newton rested wholly on the sure basis of experiment, the mighty superstructure could not have been reared without the exertion of a mental vigour far beyond that which usually characterizes men of genius, and the attainment of a degree of science which has seldom if ever been equalled. Profoundly skilled in mathematics, he brought the abstract sciences to bear with admirable effect on the knowledge derived from the contemplation of nature, and was led on from facts and phænomena to general principles and laws—from experimental proofs, by an unbroken chain of inductive reasoning, to universal truths and doctrines of universal application. "He knew," remarks Professor Playfair, when instituting a comparison between the genius and philosophy of Leibnitz and Newton, "he knew how to transfer the truths of abstract science to the study of things actually existing, and, by returning in the opposite

direction, to enrich the former by ideas from the latter. In experimental and inductive investigation, he was as great as in the pure mathematics, and his discoveries were as distinguished in the one as in the other. In this double claim to renown, Newton stands unrivalled; and though in the pure mathematics, perhaps equals may be found, no one will come forward as his rival, both in that science and in the philosophy of nature."—"No one ever left knowledge in a state so different from that in which he found it. Men were instructed not only in new truths, but also in new methods of discovering truth; they were made acquainted with the great principle which connects together the most distant regions of space, as well as the most remote periods of duration, and which was to lead to future discoveries, far beyond what the wisest or most sanguine could anticipate."*

If the preceding remarks on the genius of Newton, and the character of his philosophy, be well founded, (and the writer has purposely availed himself of the opinion and authority of others, rather than obtrude his own sentiments,)—if such be the distinguishing excellencies and such the glorious results of the mode of philosophizing practically adopted by himself, and recommended to others, scarcely can we wonder that of him it should have been said, in the language of high but well-merited panegyric—

"Nature and Nature's laws lay hid in night,
God said, 'Let Newton be,' and all was Light."

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* Playfair's Second Diss. pp. 89, 90.

CHAPTER IV.

THE PROGRESS OF THE INTELLECTUAL SCIENCES.

SECTION I.

ON THE GRADUAL SUBVERSION OF THE SCHOLASTIC PHILOSOPHY.

352. IT is now requisite to revert once more to the memorable period of the revival of letters, for the purpose of tracing the progress of intellectual and moral science, and of observing the manner in which the human mind was emancipated from the bondage in which it had been long held. At the commencement of that period, the despotism of Aristotle and the authority of the schoolmen were at their height. Upheld by all the influence and power of the Roman hierarchy, which as yet scarcely an individual had ventured to resist, the scholastic philosophy (if such it may be termed) had taken so firm a hold of the opinions and prejudices of mankind, that it might seem impossible to shake it. Yet the period was at hand, and latent causes were even then in operation, which slowly undermined, and eventually laid in ruins this mighty fabric. Some of these have been already enumerated in the section, which treated of the causes of the revival of letters. For whatever tended to weaken the authority of the Church of Rome, to excite a taste for general literature, and to awaken the spirit of inquiry and

reformation, could not fail, in an equal degree, to shake the foundations of a system, which originated in ignorance and error, and had been perpetuated by superstition and priestcraft. Some of the causes to which we now allude, wrought silently and indirectly, while others assumed the character of open and direct hostility to the dogmas of the schoolmen.

353. The most effectual *indirect* cause of this intellectual change, was the *restoration of learning*, (in the proper sense of that term,) after it had long remained in a state of torpor, and had almost ceased to exist. A considerable body of genuine scholars simultaneously appeared in different parts of Europe, whose erudition not only procured for them personal distinction, but exerted an influence far beyond their most sanguine expectations. At the head of this illustrious phalanx, stood ERASMUS of Rotterdam, whose philological labours, both in sacred and profane literature, were most extensive and valuable. With him were associated not a few, both of the Protestant and Roman catholic communions, who were animated by the same spirit, and engaged with equal ardour in the work of liberal and enlightened criticism. Of this number were *Ludovicus Vives*, *Budæus*, *Faber*, *Reuchlin*, *Julius Scaliger*, *Sir Thomas More*, and *Melancthon*, with many others. At this most interesting period, the critical investigation of the Sacred Scriptures commenced. Materials were sought with the utmost solicitude from every quarter for this purpose. The monastic libraries were explored wherever access could be obtained to them; and manuscripts of the Old and

New Testament were brought thence and collated, if not with the accuracy of modern philologists, yet with a degree of diligence that was highly commendable. Critical commentaries and philological annotations on the several books of Scripture began to multiply; and the cognate languages of the East were employed for the interpretation and elucidation of the Sacred Writings. These proceedings were more than sufficient to excite alarm at the court of Rome, and amongst the ecclesiastical authorities of that religious community, which has ever manifested a determined hostility to the diffusion of scriptural knowledge. Nor was this all. While some of these distinguished scholars directed their chief attention to sacred criticism, others employed their erudition in secular illustrations of the classical writings of antiquity; in decyphering and collating ancient MSS.; in restoring corrupted and elucidating obscure passages; and in bringing to light original works, which had slumbered for ages in their dusty depositories. Whilst engaged in these researches, they discovered that the Aristotelian philosophy, which had been taught for ages in the schools, and to which they and their fathers had been required to yield a blind submission, was widely different from that contained in the genuine writings of the Stagirite; that there were many other valuable monuments of heathen philosophy, besides those of Aristotle, though they had been proscribed by the authority of the church; and that it was possible to explore these relics of antiquity without abandoning their christian faith. These investigations were now extended to the writings of the Pythagoreans, the Platonists, the Stoics, and other ancient sects of philosophers, whose systems were explained and publicly taught, in conjunction with the Peripatetic, in some of the schools. This was, it is true, a bold innovation; it was denounced by the monks and jesuits as heretical; yet there were some learned members of the Roman catholic communion who still persisted in these studies, and, like Erasmus, retaliated on the advocates of ignorance by severe sarcasms and keen satires against clerical dissoluteness and monastic stupidity.

354. The names of some of these *literary* reformers having been incidentally mentioned, it would be an act of injustice to those benefactors of mankind, (for such they must be acknowledged to have been,) to pass them by, without further notice of their character and writings. Such notices must necessarily be brief in an elementary work like the present; but may not be unacceptable to the youthful readers of these pages.

(1.) ERASMUS was born at Rotterdam, A.D. 1467. Having lost both his parents in early youth, his guardians neglected his education, and forced him into a monastery. Here he became so well acquainted with the immoral habits of the monks, and saw so much of the profligacy which then characterized many of these professedly religious establishments, that he was well able in future years to tear off the mask, and expose to public view the mysteries of abomination they had long concealed under a mask of exemplary piety. The earliest opportunity was embraced of throwing off the yoke of monasticism, and devoting himself to the study of letters. His progress was so rapid, that he soon became, considering the age in which he lived, a prodigy of learning. His literary course commenced at Paris, but was chiefly carried on in England, where he formed an intimate acquaintance with many distinguished scholars; particularly Colet, Grocyn, Linacre, and Sir Thomas More, all of whom must be numbered amongst the earliest promoters and patrons of classical literature in this country. Many attempts were made by the Roman court to induce Erasmus to settle in Italy; but either from a secret attachment to the Reformation then commencing, or from a personal regard to his British friends and patrons, he determined chiefly to reside in England, or in contiguous parts of the continent, where he might enjoy a greater degree of independence of thought and action, than in Roman catholic countries. The more serious labours of Erasmus were philological, especially in the department of sacred criticism; as is evident from the successive editions of the Greek Testament published by him, and his commentaries on many parts of Scripture; but the keenness of his satires, the sprightliness of his wit, the exquisite humour of his sarcasms, did more than all beside to destroy the idolatry of Aristotle, to subvert the authority of the schoolmen, and to scatter the delusions of priestcraft. His works (which were collected and published after his death in ten folio volumes) afford the most abundant evidence of the versatility of his talents—the extent, if not the depth, of his erudition—and the incredible labour and industry with which he followed up his diversified literary pursuits. Though he continued professedly a member of the Roman church to the end of his life, perhaps none of the reformers (Luther alone excepted) contributed more effectually to expose the corruptions of the church of Rome, and, by doing this, *indirectly* to promote the cause of the Reformation.

(2.) LUDOVICUS VIVES was one of the many men of letters with whom Erasmus was intimately associated, and, like him, ardently devoted to general literature. He wrote on many philosophical subjects with much acuteness, and a degree of perspicuity, that forms a striking contrast to the obscurity of the scholastic writings. Erasmus testifies concerning this learned coadjutor and friend, that "when only twenty-six years of age, he excelled in every part of philosophy, and that, in the arts of speaking and writing, he stood unrivalled." After the death of Erasmus, Vives followed up the plans of his preceptor, by prosecuting still further his philological and philosophical researches; by unwearied efforts to disperse the intellectual darkness of preceding ages; by chastising, with unsparing severity, the advocates of ignorance and corruptors of the public taste; and by reviving a taste for true science and classical learning. Among the numerous treatises written by him, those which have been most celebrated are his "Essays on the Origin, Sects, and Praises of Philosophy;" on the "Corruption of Science and

Education;" and on the "First Philosophy." A modern critic has styled the writings of this eminent scholar "golden remains, which are worthy to be carefully perused by all learned men."

(3.) BUDÆUS was born at Paris in 1467, and spent his youth in dissipation and gaiety; but afterwards devoted himself to literature with such assiduity and success, as to be termed, by Erasmus, "*Portentum Galliæ—the prodigy of France.*" He was an eminent linguist and critic, and, as such, can only be said to have contributed to the advancement of philosophy by indirect means; but those means operated most effectually, though by slow degrees, to the subversion of the barbarous scholastic philosophy. Enfield, in his History of Philosophy, remarks, that "Erasmus, Ludovicus Vives, and Budæus, formed a triumvirate of literature, which did honour to the age."

(4.) FABER, or Le Fevre, was a native of Picardy, who flourished at the same period. By diligent study of the ancients, and intimate converse with the learned men of his age, he acquired a high degree of reputation for learning. He was one of the most determined opponents of the scholastic philosophy, though zealously attached to that of Aristotle. His principal works were commentaries on the dialectics, physics, œconomics, and ethics of Aristotle, which were considered so complete, as to supersede all the labours of preceding annotators. In common with most of his learned contemporaries, he suffered much persecution, and encountered many dangers, on account of his efforts to restore true philosophy from its state of degradation, particularly from the doctors of the Sarbonne; but, protected by the Protestant Queen of Navarre, he weathered the storm, and arrived at extreme old age.

(5.) Among the learned philologists and critics of that age, REUCHLIN, a native of Germany, and correspondent of Erasmus, must be mentioned. This distinguished scholar was the means of exciting an ardent and insatiable thirst for knowledge, far beyond the limits of his native country. He was the principal restorer of Hebrew learning, at a time in which the ecclesiastical authorities denounced it as dangerous and heretical; when the faculty of theology at Paris publicly maintained that "religion was undone if the study of the Greek and Hebrew languages was permitted;" and when the inquisitors of Cologne and others obtained from the Emperor of Germany an edict, which authorised the destruction of every Hebrew manuscript, as pernicious to the true faith. But the reign of ignorance was drawing to a close, and Reuchlin contributed in no ordinary degree to accelerate its fall, by his celebrated satirical epistles, entitled, "Epistolæ Virorum obscuriorum," which produced as powerful an effect in their day, as Pascal's "Provincial Letters" at a later period.

(6.) SCALIGER is a name familiar to all who are conversant with Greek criticism. The elder Scaliger (Julius Cæsar), who flourished at the beginning of the sixteenth century, and the younger (Joseph Justus), who was the literary ornament of its close, were alike famous in their day for a prodigious accumulation of critical knowledge; but the latter in a far greater degree than the former. They were the authors of an innumerable variety of critical commentaries on Latin and Greek authors, besides many on the remains of Arabian and eastern literature. But their consummate vanity and irritable disposition tarnished the glory of their reputation, and diminished the value of their writings. The younger Scaliger directed his attention particularly to chronology, and invented that arrangement of the calendar, which he designated, in honour of his father, *the Julian period.*

(7.) Sir THOMAS MORE, who occupies so distinguished a place in English history during the reign of Henry VIII., was a highly accomplished scholar, and the author of several works, both historical and critical, which have been much admired. The only production of his pen, that can be said to partake of a philosophical character, was his *Utopia,* a most extraordinary production; the sentiments of which form a striking contrast to the illiberality and bigotry of the latter years of his life. Inimical as he was to the principles of the Reformation, he maintained an intimate friendship with Erasmus, and contributed, by his erudition and writings, to undermine the tottering fabric of scholasticism, and disperse the darkness of preceding ages.

(8.) But of all the men of genius who flourished at the memorable æra of the Reformation, there is perhaps none to whom true science and sound philosophy are more deeply indebted, than to the amiable, the excellent Melancthon. With an ardent zeal for the advancement of Christian theology and the Protestant faith, he combined an enthusiastic attachment to literature, in almost all its several departments, and especially to intellectual philosophy. Unlike the great Saxon Reformer, who levelled his artillery indiscriminately against all the systems and opinions of the ancients, and all the speculations of the scholastics, Melancthon laboured assiduously to separate "the precious from the vile;" to discriminate between the profitable and true, and that which was merely theoretical and fallacious; and to substitute a rational logic for the absurd dialectics of the schoolmen. As the most effectual means of accomplishing this design, he aimed at the improvement of education in the public schools, by introducing elementary books in science and philosophy, freed from the unintelligible jargon of the writers of the middle ages. Some of these were drawn up by himself, and were very far superior to those previously in use, though they discovered an undue regard to ancient theories and systems, and were quickly superseded by the more enlarged and enlightened philosophy of the illustrious Bacon, to whom was reserved the honour of giving the final blow to the scholastic philosophy, by pointing out a more excellent way.

SECTION II.

ON THE REFORMATION OF INTELLECTUAL PHILOSOPHY BY LORD BACON.

355. THE illustrious personage, whose name is prefixed to this section — illustrious not so much on account of his title, and rank, and dignified offices, as because of the pre-eminence of his genius, and his high mental endowments — occupies the very first place in the list of intellectual philosophers, whether of ancient or modern times. He was, in the department of mental philosophy, what Luther was in that of religion—*the first of Reformers;* the great emancipator of the human mind from the thraldom in which it had been held during a long series of ages—the founder, not of a philosophical sect, bearing his name and doing homage to his memory, (like Plato and Aristotle,) but of an intellectual republic, established on the ruins of ignorance and mental despotism. Such an individual may justly demand a more than ordinary degree of attention in a work which, however elementary its character, professes to trace the progress of knowledge, and develop the history of the human mind. It will therefore be attempted, in this and some following sections, to convey a distinct conception of the state of intellectual philosophy when Lord Bacon arose — to state the principal facts of his literary history — to give a brief outline of some of his principal works — and to form an estimate of the character and influence of his philosophy, both in his own times, and in succeeding ages.

356. From statements already made, it will not be difficult to perceive that the circumstances and events which occupied public attention, when Bacon commenced his illustrious career, were highly favourable to the development of genius, and well calculated to stimulate to the utmost exertion every intellectual faculty of man. The scholastic philosophy had been assailed by wit and argument, by learning, taste, and genuine science. The Reformation had diffused its light over a great part of the European continent, and men were beginning to think, and inquire, and investigate truth for themselves, both in philosophy and religion.

Still, however, the ancient system retained its hold, and even seemed to be recruiting its strength. It was apprehended, by some persons of exemplary piety, (among whom was the amiable Melancthon,) that if all the ancient landmarks were removed, infidelity and atheism would universally prevail. They feared, that if "the veil of awful obscurity which then covered the face of nature were withdrawn, the rash curiosity of mankind would lead them to account for all appearances in the visible world, by second causes, by the powers of matter and mechanism; and thus they might come insensibly to forget or neglect the Great Original Cause of all." These pious but mistaken apprehensions led them to aim rather at a reformation of the *old*—than the establishment of a *new* system of philosophy—to labour at effecting the purification, and not the demolition of the venerated temple, of which Aristotle was the tutelar deity.

357. There were, however, some philosophers, occupying the intermediate space between the Reformation and the æra of Lord Bacon, who appear to have strongly imbibed the well-known opinion of Luther, that "it was impossible to reform either religion or philosophy, till the metaphysical theology of the schools was renounced, the authority of Aristotle subverted, and the scholastic system utterly demolished." They consequently directed all their energies to the accomplishment of these objects, though with comparatively little success.

(1.) The first of these was RAMUS, a French logician, born A. D. 1515, who may be numbered among the few who have suffered martyrdom for their philosophical opinions. Ramus was of humble origin, but manifested, in early youth, talents of no ordinary kind, by which he was gradually raised from a servile office in the college of Navarre, to one of its professorships. In this honourable station he acquired great celebrity; but, at the same time, stirred up against himself a host of enemies, by his determined opposition to the Peripatetic philosophy. Endowed with an acute and vigorous mind, and furnished with the graces of elocution, he disputed publicly in the university of Paris, against the logic of Aristotle and the schoolmen; held them up to ridicule, and exposed the most vulnerable parts of their system. In a series of publications on dialectic subjects, he steadily pursued the same object, and assailed with the utmost vehemence this venerated fabric of antiquity. Attempts were made by a few more daring combatants to vanquish him in public debate; but finding that this experiment failed, they had recourse, according to the custom of that age, to civil authority and the sword of persecution. He was forbidden to teach philosophy, or to write on philosophical subjects; and eventually compelled to take refuge in Protestant countries from the machinations of his enemies. After having taught logic in several of the German universities, he unadvisedly returned to Paris, a short time before the execrable day of St. Bartholemew, when he was massacred *professedly* as a *Hugonot*—but *really* at the instigation of Charpentain, one of the professors of the university of Paris, whom he had foiled in argument, and who was jealous of his reputation. The "Manual of Logic," published by Ramus, was compiled from the dialectics of the Platonists, Peripatetics, and Stoics. It continued, during many years, to be used in the public schools of Germany, Holland, England, and the Protestant provinces of France; but that which renders it peculiarly interesting in the present day is, that it was deemed, by the author of "Paradise Lost," of sufficient importance to employ his splendid talents, in enriching it with commentaries and annotations.

(2.) About the same period flourished in Italy, *Bruno*, a native of Nola, in the kingdom of Naples, who also must be added to the list of philosophical martyrs; for he was burned at Rome, by order of the sanguinary court of Inquisition, A. D. 1600. His speculations were bold, his opinions novel, and the character of his mind independent—crimes which have always been considered unpardonable by the advocates of intolerance and ignorance. Bruno was the author of numerous tracts on metaphysical subjects, in some of which he contends for opinions similar to those afterwards maintained by Des Cartes and Leibnitz, and which appear to have been derived from the oriental philosophy. The principles maintained by him, in his treatises on "Shadows of Ideas," on "Infinity and the Universe," and on "Monads, Number, and Figure," prove him to have possessed an acute and vigorous mind, capable of pursuing abstract speculations; but at the same time they evince that his philosophy was more Pagan than Christian. Dr. Enfield, after presenting a summary view of his metaphysical system, states, that "his doctrine appears to have been the result of an absurd attempt to unite the atomic and emanative systems of philosophy, in which mathematics, physics, and metaphysics are injudiciously confounded, and which on the whole rather served to perplex than to improve philosophy."*

(3.) Towards the close of the sixteenth century, flourished *Campanella*, a native of Calabria, in Italy, who trod nearly in the steps of Bruno, and narrowly escaped his fate. His mighty but eccentric genius prompted him to bold speculations in philosophy, and sceptical if not atheistical notions in religion. His works were numerous, on almost every topic that lies within the range of metaphysical and moral science. Of the logical system of Campanella, it is stated that, though widely different from the Peripatetic, and still more from the Scholastic, it abounds no less than they with subtle distinctions and unintelligible jargon. Nor were his metaphysical opinions less obscure than his dialectics; yet the celebrated Leibnitz, who could not be an incompetent judge of his intellectual character and attainments, estimates them so highly as to place him above Hobbes in moral science, and on a level with Bacon in intellectual philosophy.

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* Enfield's Hist. of Philos. Vol. II. 517.

358. The only valuable end attained by the writings of Ramus, Bruno, Campanella, Patricius, Nizolius, and a few others of the same class, who flourished during the sixteenth century, and filled up the space between Luther and Bacon, was, that they shook and gradually undermined the authority of the Scholastics, and, by doing this, prepared the way for the reception of a more enlightened philosophy, by whomsoever it might be promulgated. But none of these invented any thing truly valuable; they possessed not sufficient comprehension of mind to substitute a new and rational system in place of that which was crumbling beneath their touch. But it has been justly observed by Stewart, in vindication of the reputation of Ramus, (and the remark will apply to several of his contemporaries,) that "even the praise of having shaken the Aristotelian fabric, without substituting any thing more solid in its place—scanty as it may *now* appear—involves a large tribute to his memory as a philosophical reformer. Before human reason was able to advance, it was necessary that it should first be released from the weight of its fetters." There was still wanting,

however, a master genius, endowed with sufficient vigour of intellect to devise a great and comprehensive plan, which should embrace all the varieties of human science, and guide our investigations in all by a safe, if not an infallible rule. This kind of universal philosophy was the great object which Bacon pursued, as the end of his intellectual researches. "If," says one of his numerous biographers, "we stand surprised at the happy imagination of such a system, our surprise redoubles upon us, when we reflect that he invented and methodized this system, perfected so much, and sketched out so much more of it, amidst the drudgery of business and the civil tumults of a court. Nature seems to have intended him peculiarly for this province, by bestowing on him with a liberal hand all the qualities requisite—a fancy voluble and prompt to discover the similitudes of things—a judgment steady and intent to note their subtlest difference—a love of meditation and inquiry—a patience in doubting—a slowness and diffidence in affirming—a facility of retracting—a careful anxiety to plan and dispose. A mind of such a cast, that it neither affected novelty nor idolized antiquity—that was an enemy to all imposture—must have had a certain congeniality and relation to truth. These characters, which, with a noble confidence, he has applied to himself, are obvious and eminent in his '*Instauration of the Sciences*,' a work designed by him, not as a monument to his own fame, but a perpetual legacy to the common benefit of others."*

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* Vide Mallet's Life of Bacon, prefixed to a complete edition of his Works, published in 1740, in 4 vols. fol. (p. lx.)

SECTION III.

SKETCH OF THE LITERARY HISTORY OF LORD BACON.

359. FRANCIS BACON, a younger son of Sir Nicholas Bacon, Lord Keeper of the Seals during the reign of Queen Elizabeth, was born at York House, in the Strand, A. D. 1561. When twelve years old, he was entered of Trinity College, Cambridge, where his progress in learning was so rapid, that he is said, before he had attained his sixteenth year, to have run through the whole circle of the liberal sciences, as then taught in that ancient university, and even to have formed a deep conviction of the necessity of some surer guide in the investigation of truth, than the theoretic philosophy then in vogue. In his nineteenth year, while resident at Paris, he composed his first treatise, containing "Observations on the State of Europe," which, though short, afforded sufficient indications of the pre-eminence of his genius. The early loss of his father, and his own comparatively straitened circumstances, rendered it necessary that he should withdraw for a time from his literary pursuits, and devote himself to the study of law; but even while thus employed, he found leisure to write another treatise, entitled "The greatest Birth of Time," the object of which, as far as it can now be ascertained, was, to point out the defects of learning, and the best means of supplying them. It is much to be regretted, that this early production of the mighty

genius of Bacon has perished, which, it should seem, from some parts of his correspondence, contained the first outline of that system of philosophy, subsequently developed in his principal works.

360. Passing over the events of Bacon's political history, as foreign to the design of this volume, this illustrious individual will at present be regarded alone as the father of experimental philosophy in all its branches, and the inventor of an enlightened logic, founded on the principles of right reason. To this view of his literary character the inestimable writings of this great philosopher bear ample testimony. The first of these was his well-known and justly-admired treatise on the "Progress and Advancement of Learning" *(De Augmentis Scientiarum)*, which made its first appearance in 1605, though the subject of which it treats had long before occupied his thoughts and studies. This was followed, in 1610, by a treatise on "the Wisdom of the Ancients," which bears the same characters of original inventive genius, and in which the proposed object of his former work was steadily pursued, and carried forward most successfully. In 1620, his great work, entitled "*Novum Organum*," was published, which formed a second part of his "Instauration of the Sciences;" the treatise on the "Advancement of Learning" being now considered as its first division. Next to these were published, at different periods, and amidst the pressure of state affairs, the results of his physical researches and experiments in a series of treatises on the phænomena of the universe, natural history, and

many other branches of practical science. The whole train of his philosophical productions terminated with his "*Scala Intellectus*," a highly intellectual dissertation; intended to trace the steps by which the human mind ascends in its philosophical researches, from the lowest grade to its highest degree of elevation: from insulated facts to general truths; from the simplest elements of knowledge to the perfection of science. The "Historical Tracts" and "Moral Essays" were among the latest productions of his genius, and, together with many of his philosophical pieces, were written after his political fall and degradation. The Lord Chancellor Bacon terminated a life of extraordinary mental exertion and activity, in 1626, in the sixty-fifth year of his age.

361. But, to form a distinct conception of the intellectual qualities of Lord Bacon, and a correct estimate of the value of those celebrated works which are unquestionably to be reckoned among the *chefs d'œuvres* of human genius, it is requisite to view them in their relative connexion; for they constitute, in reality, but one magnificent whole, and afford an exquisite specimen of the "*Scala Intellectus*" which he recommends to others. In the first of the abovementioned works, (the treatise, "*De Augmentis*,") the author proposes to take a general survey of human knowledge, contemplating the intellectual faculties under the three great divisions of Memory, Fancy or imagination, and Understanding. Corresponding with these, all the arts and sciences are classed under three heads,

namely, History, Poetry, and Philosophy. Under each of these, an inquiry is instituted into what is erroneous or defective; and the most proper means are suggested for correcting the errors, amending the defects, and supplying the omissions in all. The next surveys the works and discoveries of the ancients, and both enumerates and estimates the inventions of past ages, tracing out, as in one general chart, the several tracts of science that still lay uncultivated and waste, and suggesting, as he proceeds, the most desirable improvements and the probable discoveries to be made by future philosophers. Having thus cleared the way for his great and principal design, he proposed, in his "*Novum Organum*," to "raise and enlarge the powers of the mind by a more useful application of its reasoning faculty, to all the objects of philosophical research." In this admirable treatise a new and rational logic is exhibited, which forms a striking contrast to that of the Scholastics; a logic calculated, not to supply arguments for controversy, but arts for the use of mankind—not to triumph over an enemy by subtle and sophistical disputation, but to subdue nature itself by experiment and analysis." Rejecting with deserved contempt the logomachies of the schoolmen, he recommends a careful *induction*, that examines scrupulously the data on which reasonings are founded; views them in every possible light; rejects all that is not necessarily included in the subject, and draws its conclusions with truth and certainty. By this his celebrated *method of induction*, which forms a distinguishing feature of the philosophy of Lord Bacon, the noblest theory has been exhibited to mankind for the investigation of physical and moral truth, that the human mind has ever conceived.

362. A solid foundation having been thus laid in a clear and rational logic, this enlightened philosopher points out, in his remaining philosophical works, its right application, by collecting and furnishing a prodigious mass of experimental facts in physical and moral science. This vast collection, the result of patient and unwearied research continued during many years, was not arranged and made public till after his death. It may be considered as an important step taken towards a complete *History of Nature.* The phænomena of the universe are classified under three general divisions: (1.) the history of *generation,* or the production of all the species of created existences, according to the ordinary course of nature; (2.) the history of *pretergeneration,* or those productions which deviate from the stated rule; (3.) the history of nature as modified, improved, altered, or debased by *human art.* The design of this philosophical inquirer, in making this collection of facts, he has stated to be "to construct a "*Scala Intellectus,*" by which the human mind may regularly ascend in its intellectual researches, and thus to furnish materials for a true and useful philosophy." All these, however, were regarded but as the preparatory steps to a yet more magnificent project which he meditated, but did not live to accomplish — that of establishing, on the

immoveable basis of experiment, a philosophy purely axiomatical and scientific, freed from all visionary speculations, and all uncertain conjectures and theories, resulting from that just and patient investigation of natural phænomena, of which his own writings furnish so admirable a model. "Such," says his biographer, and the learned editor of his works, "such, and so unlimited were his views for the universal advancement of science. Such was the noble aim to which all his philosophic labours were directed. — What Cæsar said, in compliment to Cicero, may, with justice, be applied to him: that it was more glorious to have extended the limits of human wit, than to have enlarged the bounds of the Roman world. Sir Francis Bacon really did so: a truth acknowledged, not only by the greatest private names in Europe, but by all the public societies of its most civilized nations. France, Italy, Germany, Britain, I may add, even Russia, have taken him for their leader, and submitted to be governed by his institutions. The empire he has erected in the learned world, is as universal as the free use of reason, and the *one* must continue till the other is no more."*

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* Vide Bacon's Life, ut sup. p. 65.

SECTION IV.

SUMMARY VIEW OF THE PHILOSOPHY OF LORD BACON.

363. THE influence of Lord Verulam's writings on the progress of knowledge and genuine philosophy has been so great, that they may justly demand a more distinct review than the general sketch attempted in the last section. A brief outline will therefore be given, in the present, of the numerous and highly important topics introduced into his principal work, (the "*Novum Organum*,") a work, which contains the full development of his new and admirable method of philosophizing.

(1.) The first object proposed, and which is obviously a prerequisite to the discovery of truth, is the detection of the principal causes of error. These (which in figurative language are termed *idols*, because they are a kind of false divinities, to which the mind of man had been long accustomed to do homage,) are classed under four heads, which he designates, *Idols of the Tribe—of the Den—of the Forum*—and *of the Theatre*. The *former* includes all those erroneous conceptions which are found to pervade human nature *generally*, and originate in principles common to all mankind; such as the love of system, the disposition to theorize, and the propensity which exists in all men to attribute effects to inadequate or imaginary causes. The *second* comprehends all those sources of error which arise out of the character and mental constitution of *individuals;* some of whom are carried away by their imaginations; others by their fondness for speculation and novelty; others by their love of controversy, or their taste for dialectic subtilties. The works of Aristotle, and the golden dreams of the alchemists, are alluded to as furnishing memorable specimens of this class of mental aberrations. The *third* embraces those errors, which arise out of the social relations of mankind, and especially which result from the imperfection of language as a medium of intercourse and vehicle of thought. By the *fourth,* it was intended to characterize those deceptions and illusions which may be traced to the imagination, or are the result of abstract speculation. Such were the dogmas of the schoolmen, and the physical systems of antiquity. The latter were again subdivided into the *sophistical,* or those into which the mind is betrayed by false reasonings; and the *empirical,* or those in which it is misled by imperfect experiments, as is usually the case in the infancy of science.

364. (2.) After this minute and philosophical analysis of the sources of error, Bacon proceeds to illustrate and demonstrate them by facts drawn from the history of mankind. This is the great object of his learned and elaborate review of the learning of the ancients, under the threefold division of the Greeks, the Romans, and the western nations of Europe; shewing distinctly how knowledge had been obstructed and truth obscured during all these successive stages of the history of the human mind, by one or other of the causes of error stated above.

Particularly is the great erudition of the author employed in gathering proofs from the records of antiquity, that these perversions had chiefly arisen from neglecting the study of nature—from an undue reverence to authority, and from the fact that ancient philosophers considered it beneath them to investigate the causes of ordinary phænomena, confining their attention to occult qualities, and whatever was mysterious and uncommon in the operations of nature. In opposition to these fruitful sources of delusion, he urges upon men of learning the diligent *investigation of nature,* and the unfettered pursuit of truth, whithersoever it may lead.

365. (3.) The necessary preliminary steps having been taken, the illustrious author advances to a more distinct explanation of his *method of induction,* as that which can alone lead to the detection of error and discovery of truth. Here he shews that the primary object to be attained is to ascertain facts, or, in other words, to collect the *history of nature.* The next is, by a comparison of these facts, to endeavour to find out the *cause* of each particular phænomenon, or (to adopt his own phrase) its *form,* by which term he designed to express the permanent qualities, and not merely the outward configuration of any substance. To ascertain those *forms,* two processes of investigation are recommended, which he technically terms "*latens processus*" and "*latens schematismus;*" the first of which denotes the secret invisible progress by which physical changes are effected; the second indicates the hidden structure or composition of bodies, on which

those changes frequently depend; *e.g.* in mechanics we inquire into the phænomena of nature by means of the *latens processus*—in chemical researches and experiments, by that of *latens schematismus.* On this firm and solid basis rests the whole superstructure of the inductive or experimental philosophy, which first excludes from the investigation of *forms* or *causes* those properties which are either accidental or hypothetical, and then proceeds by a careful analysis to the establishment of general principles and laws. In other words, it is laid down as a rule of universal application, that "whatever may be the case with superior intelligences, man can only attain knowledge by beginning with *negatives*, and proceeding to *affirmatives*."

366. (4.) It was the boast of the Peripatetic philosophers, that the famous *categories* of their great master included all the objects of human knowledge philosophically arranged. But with far greater propriety might this be asserted with reference to the classification of *facts*, or *instances*, which Lord Bacon has introduced into his "Novum Organum," and illustrated by numerous examples. It is not possible, without extending unduly the limits of this work, to convey any adequate idea of this important division of the philosophical system of Lord Bacon; yet it would be still more inexcusable to pass it over unnoticed. As a middle and more convenient course, a simple enumeration will be made of the twenty-seven classes, or species of facts, which are distinctly mentioned, with one example of each, selected out of many adduced by

the illustrious author. It will be perceived that the titles are, in some instances, quaint and fanciful; but they for the most part happily express the meaning they are intended to convey.

In order to prove the utility and importance of experimental knowledge, to facilitate the investigation of nature, physical facts (termed by the philosopher "*prærogativæ instantiarum*") are arranged as follows:

1. *Solitary*---illustrated by the doctrine of colours.
2. *Migrating*---exemplified by physical changes of form, &c.
3. *Ostensive* or *convincing*---as in the case of the thermometer.
4. *Clandestine*---as in the magnet or loadstone.
5. *Constituent* or *collective*---as in the process of memory, &c.
6. *Parallel* or *conformable*---as in the human eye and lenses.
7. *Singular* or *heteroclite*---as the sun among the stars.
8. *Deviating* or *irregular*---as in the case of monsters.
9. *Frontier* or *boundary facts*---as moss, bats, and apes.
10. Those which indicate *power*---as inventions and discoveries.
11. *Accompanying* and *hostile*---as fire and smoke, or air and solidity.
12. *Subjunctive* or *extreme*---as gold in weight, the whale in bulk, iron in hardness, &c.
13. Instances of *confederacy* and *alliance*---illustrated by attraction.
14. *Crucial facts*, or *those which decide doubtful questions*---illustrated by the tides.
15. Instances of *divorce* or *separation*---as in the accidental qualities of bodies, or the phænomena of magnetism.

16. Those of the *gate,* the *portal*---e. g. the telescope and microscope.
17. *Summoning facts*---as when latent properties are brought to light by experiment.
18. *Progressive*---as in the processes of vegetation and nutrition.
19. *Supplemental* or *substitutive*---as in chemical affinities and combinations.
20. *Lancing* or *vellicating facts*---those by which the understanding is *forcibly* reminded of remarkable phænomena.
21. *Measuring* or *terminating facts, which relate to space and distance*---as in percussion or attraction.
22. Those of the *course* or *regular motion*---as in the propagation of sound or the velocity of light.
23. Those of *quantity*---as in drops of dew, or the ocean.
24. *Reluctant,* or those indicative of the *inertia* of matter: (under this class, all the varieties of motion are considered.)
25. *Intimating facts,* or those which suggest others.
26. *Sovereign* or *general,* including those which have been fully established by numerous experiments.
27. *Magical facts,* or those in which marvellous effects are produced by apparently trifling causes.

Of the above classification of *instances* it may be remarked, that fifteen relate to the understanding, five to the senses, and the remaining seven to the practical arts and sciences. It is a lasting memorial of the ingenuity and profound wisdom of its inventor, and fully justifies the following high eulogium, pronounced by the late Professor Playfair, at the close of his elaborate and admirable analysis of the Novum Organum:---" The power and compass of such a mind, which could form such a plan beforehand, and trace not merely the outlines, but many of the most minute ramifications of sciences which did not yet exist, must be an object of admiration to all succeeding ages. He is destined (if indeed any thing in the world be so destined) to be an *instantia singularis* among men; and as he had no rival in times past, he is likely to have none in those which are to come. If ever a second Bacon is to arise, he must be ignorant of the first."—(*Vide Playfair's Diss. ut sup.* p. 55.)

SECTION V.

GENERAL VIEW OF THE INTELLECTUAL CHARACTER OF LORD BACON.

367. MANY of the distinguished names which have occurred in former sections are identified with some one department of science, in which they excelled, and where their efforts proved most successful. Few, comparatively, are those who have acquired honourable distinction in both the great divisions of human knowledge, scientific and intellectual; and among these, Lord Bacon stands preeminent. Galileo, Kepler, Huygens, and, above all, Newton, may perhaps rank above Bacon, both in mathematical and physical science; but, if we except the last of the illustrious train of natural philosophers just enumerated, their views even on physical subjects were far less comprehensive than those of Bacon; and in intellectual science they were

utterly unable to approach him. While pursuing their most brilliant discoveries, the former were led on step by step without any anticipations of the developments of future ages; but the latter seems to have astonished both his contemporaries and his successors, by a long catalogue of *desiderata* and *facienda,* by his almost prophetic visions of futurity. Upborne by his mighty genius, as to the summit of some lofty mountain, his eagle sight penetrated through the surrounding darkness, and saw, dimly and indistinctly indeed, but yet with sufficient clearness to guide future inquirers, the vast regions of experimental philosophy, which have since been traversed in every direction.

368. But merited as is the renown of Lord Bacon, acquired by his physical researches, it is manifest from his writings, that he was more completely at home in intellectual philosophy; and that, if the properties and laws of *matter* were subjects, to the investigation of which the force of his genius was frequently directed, those with which he was most familiar, and in which he most delighted, were the phænomena of mind,—" the laws, the resources, and the limits of the human understanding."

(1.) As a profound *logician,* Bacon stands unrivalled. Despising the subtilties, which, during many ages, had been mistaken for true science; passing over, with silent contempt, the absurd logomachies of the schoolmen, he devised a method of reasoning at once the most simple and conclusive—that of legitimate induction. The object of this inductive process of reasoning is, by ascending from axioms, or self-evident truths, to principles of universal application, to arrive at demonstration and absolute certainty; just as in physics, we are led onward from individual facts, by a series of experimental proofs, to the discovery of some general law of nature. That this most satisfactory process should have effectually subverted the scholastic logic, without any attempt, on the part of its author, to expose the absurdities and sophistry of the schoolmen, might reasonably have been expected; nor would it require much penetration to perceive, that such a work as the "Novum Organum," could not fail to produce a new æra in the dialectic art.

369. (2.) With logic, *universal grammar*, or the theory of language, is closely connected. Nor did this escape the penetrating genius of Bacon, though his aphorisms on this subject must rather be considered as hints suggested to future logicians, than systematically arranged. His inquiry into the mutual influence of thought and language is most important, and still remains as a highly interesting object of philosophical research. The distinction made by him between grammar, considered as a branch of literature, and as a department of philosophy, affords a fine specimen of the enlarged, the comprehensive, the almost boundless view he was accustomed to take of whatever subject fell beneath his notice. The former is chiefly concerned in tracing out the analogies and relations of words among themselves; but the latter aims at the discovery and adjustment of the relation between words and things,—it is the sensible portraiture of the mental

process. This important subject, which was first brought forward in a transient but masterly manner by Lord Bacon, has of late years been discussed by philosophers of no ordinary name, with distinguished success.

370. (3.) Bacon was too sound a philosopher to attempt the establishment of a metaphysical system, or aim at the construction of a complete theory of the human mind; though it is scarcely possible to conceive of a human being better qualified for the undertaking. But he was an avowed enemy to systems and theories: he accounted them the most fruitful sources of error; and therefore determined to be ever on his guard against an *ignis fatuus*, by which so many had been bewildered. He touches, it is true, in almost every part of his writings, on the intellectual phænomena. He treats separately of the more important faculties of the understanding, and their various modes of operation. He delights to dwell on the capacities and *improveability* of the human mind: but amidst all the enthusiasm of his genius, when expatiating on these subjects, he never loses sight of the present imperfection of human knowledge, or lays aside the modesty and humility of a true philosopher.

371. (4.) The ethical writings of Bacon, though less celebrated than his treatise on logic and metaphysics, are no less characterized by profound thought, inventive genius, brilliant fancy, and correct reasoning. Respecting these moral disquisitions, it is remarked, that " on the influence of custom and the formation of habits, Bacon has opened some new

and interesting views: a most important article of moral philosophy, on which he has enlarged more ably and more usefully than any writer since Aristotle." Under the same head of ethics may be mentioned the small volume to which he has given the title of Essays, the best known and most popular of his works. It is also one of those in which the superiority of his genius appears to the greatest advantage, the novelty and depth of his reflections often receiving a strong relief from the triteness of his subject. It may be read from beginning to end in a few hours; and yet, after the twentieth perusal, one seldom fails to remark in it something overlooked before. "This, indeed," adds the same elegant and judicious writer, "is a characteristic of all Bacon's writings, and is only to be accounted for by the inexhaustible aliment they furnish to our own thoughts, and the sympathetic activity they impart to our torpid faculties."*

(5.) The only points of view in which it is requisite farther to glance at the philosophical character of this great man, relate to the departments of *political philosophy* or *jurisprudence*, and *education*. The former of these pervades his state papers, letters, and histories;—the latter is advocated with much eloquence and erudition in one of his treatises, entitled, "*The Georgics of the Mind*;" the object of which is not only to prove the importance of education, but to suggest rules for the development and improvement of the intellectual character,—a work worthy of its illustrious author, and particularly deserving of attention in the present day, when education is making such rapid progress among all classes of society.

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* Stewart's Diss. ut sup. p. 54.

SECTION VI.

SKETCH OF THE LIFE AND WRITINGS OF DES CARTES.

372. ALTHOUGH the distinguished philosopher, whose literary biography is now to be sketched, flourished nearly forty years after Lord Bacon, it does not appear, from any part of his numerous writings, that he was acquainted with the works of our great English philosopher. It is scarcely possible that he should have been ignorant that such works existed; for they are not unfrequently alluded to, and even quoted by some of his learned correspondents. The topics to which the philosophical treatises of Bacon relate, are so similar to many of those which occupied the attention of Des Cartes, that it might have been reasonably expected he would be solicitous to know what had been previously written on these subjects, by a man whose fame had already resounded throughout Europe. It is probable that the true reasons of Des Cartes' ignorance of these writings, or rather his silence respecting them, were, either that he was too busily occupied through life with his own abstractions and speculations, to find leisure to cultivate an extensive

acquaintance with those of others; or that his disposition to theorize and speculate, disinclined him to pursue the cautious mode of philosophizing recommended by his illustrious predecessor, and disqualified him to estimate fairly his merits. However this may have been, it is certain, that scarcely a greater contrast can be imagined, than that which may be perceived both in the intellectual character and habits, and in the philosophical systems of these two distinguished personages. In proof of this remark, a brief sketch will be attempted, in the present section, of the literary history of Des Cartes; and in the next, a summary view given of the Cartesian philosophy.

373. **Renez Des Cartes** was born in the department of Touraine in France, A. D. 1596. Whilst yet a child, he was characterized by an insatiable curiosity to know the reasons of things which attracted his notice, and to trace effects to their causes; thus affording a very early presage of his future eminence in intellectual philosophy. He received the first elements of knowledge at the Jesuits' College of La Fleche, which was then, and long afterwards, a famous seat of classical and mathematical learning. Disgusted, however, with the scholastic method of education which then prevailed, he abandoned for a time all literary pursuits, entered the army, and fought, during several campaigns, under the banners of Prince Maurice de Nassau, in Holland, and Maximilian of Bavaria, in Germany. While pursuing his military career, Des Cartes gave himself up to habits of mental indolence and

dissipation, from which he was with difficulty reclaimed by the earnest exhortations of some friends of his youth, who had justly appreciated his talents, and lamented their perversion. At their solicitation he quitted the army and the gaming-table, for deep retirement and laborious study. Several years were subsequently devoted to visit the principal cities of Europe, for the avowed purpose of forming and cultivating a personal acquaintance with the most celebrated mathematicians and philosophers of the age. After having accomplished this object, he determined to settle at Paris, and pursue, with the utmost vigour, his philosophical researches. During this important period of his life, the mind of this great philosopher appears to have experienced a change, no less remarkable than that which had appeared in his conduct. After passing through a most distressing process of almost universal scepticism, it settled down, at length, into a solemn conviction of the great principles of moral and religious truth, and a fixed determination to employ the residue of life in their investigation. It was during the earlier stages of this mental process, while his mind was yet unsettled and sceptical, though anxiously inquiring after truth, that the first part of the celebrated ethical "Treatise on the Passions" was written,—a fact which will sufficiently account for the wide difference which cannot but be perceived between the earlier and later writings of Des Cartes, and which will also account for the sarcastic sneer of a modern infidel writer, who states, "that Des Cartes began with doubting of every thing, and ended in believing that he had left nothing unexplained." His first treatise "On the Passions," (to which he owed much of his celebrity,) was written in 1629; the second part, which is of far greater value, did not appear till A. D. 1646, a short time before his death.

374. After having pursued, during several years, a train of moral and philosophical inquiries into the physical and natural proofs of the existence of God, the immortality of the soul, and its various modes of operation, Des Cartes gave to the world the results of those profound metaphysical speculations in a treatise, entitled "Philosophical Meditations on the First Philosophy," which was first published in 1633; in which were developed the elements of what has since been termed, the *Cartesian Philosophy*. About the same time, several tracts were produced by him on subjects connected with different departments of physical science, particularly on "Meteors," and on "Astronomy," or the System of the World, and on Optics. In consequence of these successive publications, the name of Des Cartes became celebrated throughout Europe. His works were eagerly sought, and translated into almost all the European dialects. Schools were founded in which his philosophy was taught, and a vehement contest arose between the advocates and opponents of the Cartesian system. The Jesuits having effectually driven him from his native country, princes and sovereigns became anxious to secure to themselves the honour of patronizing this renowned philosopher. Attempts were first made by the States-General of

Holland to induce him to fix his residence in that country, which were in part successful; as it is known that some of his principal works were written and published there. These were, his treatises on "Mechanics, Dioptrics, and Geometry;" his logical work, entitled "De Methodo;" and his most celebrated performance, "Principia Philosophiæ;" all of which appeared between the years 1637 and 1641. Charles I. of England, promised him a liberal appointment and efficient patronage; but the commencement of the civil war, which terminated in the death of that unfortunate monarch, prevented his acceptance of these offers. At length female influence prevailed; Des Cartes yielded to the flattering solicitations of Christina, Queen of Sweden, who invited him, with many others, to her capital, for the purpose of forming there an academy of sciences, similar to those previously established in other European cities, and removed to Stockholm, A. D. 1649, where he died in the following year.

375. The preceding are the principal facts connected with the personal history of Des Cartes; but few comparatively of his numerous writings have been specified. They relate to almost every subject connected with physical, intellectual, and moral science. From statements already made, it will appear that he ranks with the profoundest mathematicians of his age. In physics, as in intellectual philosophy, he was frequently diverted from the sober track of induction and experience, by his love of abstract speculation, and the stress laid on *à priori* reasonings; but in the department of logic,

he rendered valuable service, by simplifying that which had been long perplexed, and reducing to a few intelligible principles, the rules to be observed in the investigation of truth.

SECTION VII.

SUMMARY VIEW OF THE CARTESIAN PHILOSOPHY.

376. IN taking a brief retrospect of the philosophy of Des Cartes, as far as relates to intellectual science, the topics may be arranged under three heads; *logic*, *metaphysics*, and *ethics*.

I. LOGIC.

This is chiefly contained in his "Dissertation on the Method of using Reason rightly in the Investigation of Truth." In that short but valuable treatise, the following general principles are illustrated and established, which at once commend themselves to our understandings by their reasonableness and practical utility, and prove how completely the author of such a logical system must have thrown off the trammels of the Scholastics. 1. That truth is to be the one great object pursued by the human mind in all its investigations. 2. That nothing is to be admitted as true in moral science, without evidence sufficient to convince every rational inquirer; or, in the abstract sciences, without complete and absolute demonstration. 3. That, in the investigation of truth, all prejudice and precipitancy of judgment are to be carefully avoided, by which the mind may be obstructed in its operations, and betrayed into false conclusions. 4. That difficulties and objections are not be shunned, but, on the contrary, most fearlessly encountered; and that it is the office of logic so to methodise and arrange them, that they may be fairly met and satisfactorily solved. 5. That in all moral reasonings, arguments and evidences are to be brought forward in their natural order, beginning with the simplest and most self-evident principles; and rising by degrees to the most complex and difficult deductions. 6. That no chasms be admitted in the argument; but that all the successive steps be so closely connected, that the relation of each to the whole may be apparent. These general rules form the basis of the entire system of logic inculcated by the Cartesians, and it will be perceived that they are taken from the practice of geometricians, and that their reception must be fatal to the domination of the schoolmen. The use and application of these principles in the investigation of natural phænomena, and the pursuit of intellectual science, are distinctly pointed out; and it had been well if their inventor had inflexibly adhered to them in his own philosophical researches.

II. METAPHYSICS.

377. This division includes those speculations on the material universe and on the phænomena of mind, which form the characteristic features of the Cartesian philosophy.

(1.) All substances, according to this system, may be comprehended under two heads—matter and mind: the essence of the former is *extension;* of the latter, *thought.* Matter, as extended, must have a real existence; and since extension applies to it *universally,* there can be in nature (that is, in the physical system of the universe) no *vacuum:* for every where must be found the essential qualities of matter;—length, breadth, and thickness. Matter, considered with relation to its primary or elementary parts, is both indivisable and unmoveable; and all the varieties of configuration it assumes, depend upon the motion communicated to them; which motion consists in the removal of one body out of its own place into that of a second contiguous to it, and this into a third; by which means it is propagated *seriatim* to the utmost boundaries of the universe. This motion was originally impressed on matter by God himself, and is regulated by certain fixed laws.

(2.) On these data, Des Cartes founded his well-known theory of the *vortices,* supposed to occupy the vast regions of space; which, as constituting the most curious and fanciful part of the Cartesian system, it will be proper briefly to explain. It was conceived, that the vast regions of space are filled with a fluid mass, portions of which are attached to the several celestial bodies. A vast quantity of this ethereal fluid revolves round the sun as the great centre of the solar system. Each planet has its own separate vortex, with constantly moves with the solid body to which it is attached, while at the same time it forms also a part of the general vortex of the solar system. The satellites of the planets have also their lesser and interior vortices, which revolve round their primaries, together with the satellites themselves, in the same direction, and with greater or less velocities, according to their distances from the sun. With these exterior and interior vortices, the whole material system was imagined to be so completely filled, that no possibility existed of a vacuum; since every particle in motion must occupy the place which another previously held, and thus move the entire system, as a drop of water, poured into a vessel, puts in motion the whole mass.—Such, according to the Cartesians, was the material universe; a space filled completely with indefinitely small corpuscles, all of which are in perpetual motion, and of grosser parts or masses of congregated particles, which compose the earth and planets. Upon this imaginative theory, Des Cartes has attempted, in his "Principia Philosophiæ," to explain all the ordinary and extraordinary phænomena of nature.

(3.) The more interesting and important division of the Cartesian philosophy relates to the operations of mind, as distinguished from matter. To the honour of this great philosopher it is stated, that he was the first of all the mental philosophers, who clearly and distinctly pointed out the manner in which the understanding acts on itself, and acquires knowledge, by reflecting on its own internal phænomena. "Des Cartes," says Professor Stewart, "was, I think, the first who clearly saw that our idea of mind is not direct, but relative;—relative to the various operations of which we are conscious. 'What am I?' he asks, in his second Meditation:—'a thinking being; that is, a being, doubting, knowing, affirming, denying, consenting, refusing, susceptible of pleasure and pain. Of all these things I might have had complete experience, without any previous acquaintance with the qualities and laws of matter; and therefore it is impossible that the study of matter can avail me ought in the study of myself.' This accordingly is laid down by Des Cartes as a first principle in metaphysical science—that nothing comprehensible by the imagination can be at all subservient to the knowledge of the mind.*" Proceeding on this principle, but reasoning from it incorrectly, he contends that there are certain innate ideas produced within us by the Great Author of our being—the seeds of which (so to speak) are primarily sown in the understanding by the Deity, but the knowledge of which is to be accounted a reflex act of the understanding.

(4.) In speculating on the nature of the human soul, Des Cartes seems to have strangely blended the peculiarities of his physical system with more correct philosophical notions. After treating at length of the animal nature of the passions, and attempting to explain the manner in which they are physically excited to action, he proceeds to consider the soul of man, as both sensitive and rational—the conflict between the superior and inferior parts of our nature, being in reality a struggle between the *sensitive* part, or the animal spirits, and the *rational* or intellectual powers. By the result of this contest, every one, he imagined, might form a judgment respecting the strength or weakness of his soul:—if the passions reign, the body preponderates;—if they are restrained, the soul occupies her due place in the system, and the rational part of our nature exerts the influence which it was intended to maintain.

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* Stewart's Diss. ut sup. p. 92. Cartesii Meditat. Phil. ii. & iii.

III. ETHICS.

378. The moral system of Des Cartes is by no means clearly defined, though its prominent features may be inferred from the preceding sketch of his metaphysical speculations. Amidst many visionary theories and abstract speculations, some valuable principles are stated relative to the nature of virtue, the grounds of moral obligation, the relation in which man stands to the Infinite Ruler of the universe—his social duties—the government of his passions—his moral capabilities, and the perfection of his nature, as chiefly consisting in a moral resemblance to the Deity. These are, however, mixed up with numerous speculations of a more doubtful and dangerous tendency. "On the whole," it is remarked by Dr. Enfield, "the Cartesian system appears to have been in part derived from the Grecian philosophy; for it is easy to recognize the Platonic notion of innate ideas, and of the action of the soul on the body; the Aristotelian notion of a *plenum;* and the *atomic* system of Democritus and Epicurus,

in his *vortices*. Yet he must be confessed also to have discovered great depth of thought, much fertility of imagination, and unwearied diligence of research. He would, however, have occupied a more distinguished place among intellectual philosophers, if he had been less easily led astray by romantic conceptions and visionary hypotheses; had he substituted experiment for theory; and inductive reasonings for hypothetical conjectures."—(Vid. *Enfield's Hist. of Philos.* Vol. II. p. 554.)

SECTION VIII.

OF THE PRINCIPAL WRITERS ON JURISPRUDENCE, WHO FLOURISHED DURING THE 16TH & 17TH CENTURIES.

379. DURING the period which has just been reviewed, a highly important branch of intellectual science was successfully cultivated by many who occupy no mean place in the republic of letters, though the limits of the present work will admit of little more than an enumeration of their names, and a cursory notice of their most celebrated writings. The department now referred to, is that which treats of the civil and social relations of mankind; a science to which various names have been given in modern times, but perhaps that of *jurisprudence* is the most appropriate and best understood. It was stated in a former section (**241**), that before the memorable æra of the revival of

letters, political science began to be cultivated, more just and enlightened views were entertained of the principles of government, and the nature of the relations subsisting between man and man; and this was enumerated among the causes which contributed to emancipate the human mind from its bondage. Tracing backward, therefore, to that eventful period, the origin of the science in question, it will be attempted to exhibit, at one view, and in chronological order, the train of political philosophers, who flourished between the Reformation and the point at which this history terminates, — the commencement of the eighteenth century. This series commences with Machiavel, and terminates with Montesquieu.

380. MACHIAVEL was a contemporary of Luther, and, "like that great reformer, acquired, by the commanding superiority of his genius, an astonishing ascendancy over the minds of his followers;" but in this alone does the resemblance appear; for in all other features of their intellectual character, scarcely can a greater contrast be imagined.

Though comparatively destitute of learning, it was the good fortune of Machiavel to enjoy the splendid patronage of the house of Medicis, under whose auspices not a few of his numerous publications made their first appearance. It falls not within the design of the present work to notice, either his dramatic performances or historical tracts, all of which afford indications of the mighty genius of their author. The books upon which his posthumous fame chiefly depends, and which entitle him to rank among the intellectual philosophers of the age, are his "Discourses on the first Decade of Livy," which are full of moral and political reflections, and especially his most celebrated treatise, entitled "The Prince," in which he professes to lay down the maxims and rules of civil government, and describes, with prodigious energy of genius, the arts by which corrupt and arbitrary rulers may sustain their unjust authority. Widely different opinions have been formed of the design of this celebrated performance: some regarding it as a political satire, intended to excite abhorrence of despotism, and hold up tyrants to contempt, by exposing their secret machinations; while others maintain, that his political maxims, infamous as they are, were seriously proposed; and plead, in mitigation of his offence, the state of society in Italy at that period, and the prevailing errors of the times. But whatever diversity of opinion may exist with regard to the *moral worth* of this celebrated treatise, all must agree in doing homage to the transcendant talent it displays. "As an original and profound thinker," says Stewart, "the genius of Machiavel completely eclipses that of all his contemporaries. No writer, either in ancient or modern times, has ever united, in a more remarkable degree, a greater variety of the most dissimilar, and seemingly the most discordant gifts and attainments, a profound acquaintance with all those arts of dissimulation and intrigue which, in the petty cabinets of Italy, were then universally confounded with political wisdom—an imagination familiarized to the cool contemplation of whatever is perfidious or atrocious in the history of conspirators and tyrants—combined with a graphical skill in holding up to laughter the comparatively harmless follies of ordinary life."*

381. Next to Machiavel, in the order of time, but far inferior in talent and reputation, stands **Bodinus**, an eminent French civilian, who flourished towards the close of the sixteenth century. "He was the first among the moderns who united a philosophical train of thinking with an extensive knowledge of jurisprudence and history." His most celebrated work, entitled, *De la Republique*, contains much curious matter, and cannot fail to be read, even in the present advanced state of political science, and after so many highly philosophical treatises on the subject have appeared, with considerable interest. He is said, by a very competent witness, to have approached nearly, in some of his views of the philosophy of laws, to Lord Bacon, and, in his refined combination of facts, bears a strong resemblance to Montesquieu." It is not the least of the qualities that reflect credit on the memory of Bodinus and his friend *De Thou*, that, in an intolerant age and country, they were not ashamed or afraid to maintain the principles of civil and religious liberty, and earnestly to recommend their universal adoption.

382. The next, and by far the greatest of the writers of that age on political science, as well as almost every other subject connected with general

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* Stewart's Diss. ut sup. p. 33—37.

literature, was GROTIUS. Of the immense mass of knowledge accumulated by this renowned scholar, ample proof is afforded in his voluminous writings, which embrace an almost endless variety of subjects, critical, metaphysical, moral, and theological. His life was by no means that of a retired scholar; for he acted an important part in public life;—was sometimes caressed, and sometimes persecuted by the civil authorities of his native country;—sometimes entrusted with magisterial power, and sometimes doomed to tedious imprisonment: but neither prosperity nor adversity could abate his ardour or diminish his assiduity in the pursuit of knowledge. After a very eventful life, marked by an unusual succession of strange incidents, and an extraordinary degree of mental exertion, this "literary phœnix" died at Rostock, on the 28th of August, 1645. The book which has chiefly contributed to establish his reputation as a philosophical writer, is his well-known treatise, "De Jure Belli et Pacis," which long continued to be regarded as a standard work on the subject of which it treats, in the principal universities of Europe, and is still held in high estimation.

383. About the same time flourished, in the northern part of our island, the justly celebrated BUCHANAN, who, though best known as a scholar of prodigious attainment, may not improperly be classed with the civilians of his age, on account of several tracts on political science, written with all the vivacity and energy of his powerful mind. Among these, his dialogue, "*De Jure Regni*," acquired most celebrity, on account of the then state of public affairs in the British empire.

With this splendid Scottish luminary may be classed an English scholar, whose accumulation of knowledge far exceeded that of Buchanan, however inferior he might be in original genius. This was **Selden**, who flourished during the reigns of James I. Charles I. and the Commonwealth. He is distinguished as an acute philologist, a learned antiquary, and a profound jurist. His principal work on the latter of these subjects treats of the "Law of Nations, according to the Jewish Polity," in which he has evinced much Rabbinical learning, combined with general political science.

Hobbes, the philosopher of Malmsbury, properly belongs to the class of metaphysical writers, and as such will be more particularly noticed hereafter. Yet almost the whole of his far-famed productions bear, either directly or indirectly, on political science; particularly his principal work, entitled, "*Leviathan;*" his tracts, "De Cive" and "De Corpore Politico," which were chiefly written in defence of the royal cause, during the period of the Commonwealth, and in which political doctrines are maintained scarcely less objectionable than the most obnoxious maxims of Machiavel himself.

384. **Puffendorf** next occurs in the list of jurists, who flourished during the seventeenth century. This distinguished writer has been considered by some equal, and by others superior, to his illustrious predecessor, Grotius. He followed closely in the same track, as is evident from the contents of

his most celebrated work, "De Jure Naturæ et Gentium," which first appeared A.D. 1672. To the same class of writings belongs another treatise, composed by him at a later period of life, entitled, "De Officio Hominis et Civis," &c., which may perhaps more properly be considered as a methodized abridgment of his great work on "the Law of Nations," than an original production. These works, in conjunction with the before-mentioned treatise of Grotius, were, till of late years, in constant use as text-books in all our public schools. If these writings do not evince original and inventive genius, they must be acknowledged to display a clear discernment — a sound and accurate judgment — extensive, if not profound erudition—and, which is infinitely more important, a reverence for *religion*, as the basis of all social virtue and happiness.

385. Passing over Leibnitz and Locke, (both of whom will be distinctly and separately noticed hereafter,) it is only requisite to glance at the celebrated author of the "*Spirit of Laws*," who, though he belongs more properly to the eighteenth century, demands a cursory notice, as the founder of the new school of political science. MONTESQUIEU carried on most successfully the project which Bodinus and Bacon had commenced,—that of rearing a superstructure of juridical science on the basis of philosophy and history. "Instead of confining himself, after the example of his predecessors, to the interpretation of one part of the Roman code by another, he studied the *spirit* of these laws, in the political views of their authors, and in the peculiar circum-

stances of that extraordinary race. He combined the science of law with the history of political society. Convinced that the general principles of human nature are every where the same, he searched for new lights among the subjects of every government, and the inhabitants of every climate; and while he thus opened inexhaustible and unthought-of resources to the student of jurisprudence, he indirectly marked out to the legislator the extent and limits of his power, and recalled the attention of the philosopher from abstract and useless theories, to the only authentic monuments of the history of mankind."*

SECTION IX.

ON THE METAPHYSICAL WRITERS OF THE SEVENTEENTH CENTURY.

386. IT was scarcely possible that the profound researches of Bacon into the phænomena of the human mind, and the ingenious speculations of Des Cartes, should not inspire many of their contemporaries and successors with a desire to prosecute the same train of investigations. Many there were at that period, who, though characterized by a great diversity of talent, and attached to different systems, pursued with ardour this branch of intellectual science. Some of these belonged to the *sceptic*, or

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* Stewart's Diss. ut sup. pp. 144, 145.

rather the infidel school of metaphysicians, at the head of whom were *Hobbes* and *Gassendi*. Others were amongst the ablest and most zealous *advocates* of revealed truth; such as Pascal, Barrow, Cudworth, and Clarke, with many others of scarcely inferior name, who brought their commanding talents, and all the energies of their powerful minds, to bear with effect on the strong holds of infidelity and scepticism; and a few may be regarded as of a neutral class, immersed in metaphysical abstractions, and intent alone upon the establishment of some favourite hypothesis, in connexion with the philosophy of mind.

387. In attempting a rapid sketch of the principal metaphysicians of the seventeenth century, (exclusive of Bacon and Des Cartes, who have been already noticed, and Locke and Leibnitz, who will be separately considered hereafter,) we shall commence with those of the *infidel* school.

(1.) The founder of this school was HOBBES, the well-known author of "*Leviathan*," and many other tracts on subjects connected with political and moral science—a man of original genius and extraordinary vigour of mind, an acute and powerful reasoner, and a most profound metaphysician: but, unhappily, these qualities served only to render him more injurious to society, by the influence of his opinions and writings. The work in which his metaphysical system is most fully developed, is, his "Treatise on Human Nature," which is generally acknowledged to be the ablest production of his pen, though his "Leviathan" may have been more popular. In this and other philosophical tracts, he strenuously opposes the Cartesian doctrine of ideas, and maintains that *all our knowledge is to be attributed to sensation alone;* thus excluding *mind* from the universe, and reducing the human understanding to a refined species of *material mechanism.* To this philosopher may also be traced that scheme of *fatalism,* which, in modern times, has been disguised under the specious name of *philosophical necessity,* on which subject Hobbes carried on a controversy with some of the most powerful reasoners of his age. In the opinion of Professor Stewart, both Locke and Hume have been greatly indebted to the metaphysical speculations of Hobbes; the former, for some of his most valuable observations on the origin and association of ideas; the latter, for his disquisitions on the relation between cause and effect, as well as his views of philosophical necessity. Pernicious as were the opinions and writings of the philosopher of Malmsbury, when first promulgated, they obtained many admirers; and their influence is felt, especially on the continent of Europe, to the present day.

(2.) GASSENDI has been already mentioned in connexion with physical science (§ 279.); he is now to be regarded as an intellectual philosopher, in which department his talents were principally employed. His metaphysical notions accorded in almost every respect with those of Hobbes; especially with reference to the origin of ideas; for it is laid down by him as a fundamental principle on this subject, "that there is not a single object of the understanding, which may not be ultimately analyzed into sensible images." On this ground, he was one of the first and most determined opponents of the intellectual philosophy of Des Cartes, who had maintained a contrary hypothesis. Gassendi was a great admirer of the writings of Lord Bacon, from which he is said to have imbibed a taste for the Epicurean philosophy, though it is not easy to imagine what part of those writings could have produced such a result. The works of Gassendi were collected, after his death, into six folio volumes; three of which are on metaphysical subjects; the fourth, on astronomy; the fifth contains biographical memoirs of celebrated mathematicians; and the last, his literary correspondence.

(3.) SPINOZA must unquestionably be referred to the same class of infidel philosophers. He was by birth a Jew, but ultimately expelled from that communion on account of his reputed atheism. In early life, he was a zealous Cartesian; and one of his first literary productions was entitled, "a Geometrical Demonstration of the Principles of the Cartesian Philosophy." But at a more advanced period he withdrew his attention, in a great measure, from mathematical and physical science, (in both which his attainments were of no ordinary kind,) to indulge in daring speculations on matter and spirit — on the universe and its author — speculations by which he was betrayed into the grossest errors and absurdities. A crude hypothesis, (for it scarcely deserves to be designated a system,) characterized alike by its impiety and absurdity, which still continues to bear the name of its inventor, was propagated by this theorist, and obtained many followers. It was a species of *Pantheism* in words, but in reality, *latent atheism.* It chiefly consisted in representing the Deity and the material universe as the same thing,—and all events, physical and moral, good and evil, as *necessarily* resulting from the same all-pervading cause. The ethics of Spinoza were less objectionable than his metaphysical creed; but, as founded on false principles, however specious their form, they could not fail to be pernicious and dangerous. The principal works of Spinoza, in which his metaphysical tenets are developed, are entitled, "Tractatus Theologico Politicus," and "Etheca Geometrica Demonstrata;" the latter of which was written in advanced life, and first published after his death.

(4.) The three above-mentioned metaphysical writers may be contemplated as founders of new sects in philosophy. Many might be added, belonging to the *sceptic,* if not the avowedly *infidel* school of mental philosophers, who flourished during the period under review. It will however suffice to mention, and that in the most cursory manner, three who are distinguished from the rest, either by the celebrity of their writings, or the extent of their erudition. *Montaigne,* whose "Essays" are chiefly valuable, as a lively practical exhibition of the philosophy of mind—a "work," says Stewart, "*unique* in its kind, valuable in an eminent degree as an authentic record of many interesting facts relative to human nature; but more valuable by far, as holding up a mirror in which every individual, if he does not see his own image, will at least occasionally perceive so many traits of resemblance to it, as can scarcely fail to invite his curiosity to a more careful review of himself.*" *Huetius*, the friend of the learned Bochart, and himself a man of extensive erudition, though the author of a valuable defence of the christian religion, (entitled "*Demonstratio Evangelica*,") it is evident, from one of his posthumous works, "on the Weakness of the Human Understanding," which is in reality but a laboured apology for scepticism, that he can only be classed with those who have perverted metaphysical science to promote the cause of infidelity. *Bayle*, the learned author of the Biographical, Historical, and Critical Dictionary, was also the author of many tracts on the most abstruse metaphysical questions, written at different periods of his active life; some of which appeared in literary journals conducted by himself, and others in separate publications. They are chiefly controversial, and in almost every instance deeply tinged with the spirit of infidelity.

388. MALEBRANCHE is a writer of a much more interesting kind than any of those just enumerated; inasmuch as his mind seems to have been imbued with a piety, which chastened, and, in a great measure, corrected his metaphysical errors. Des Cartes' "Treatise on Man" first inspired him with ardour on philosophical subjects, and gave that bias to his intellectual pursuits which manifested itself through

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* Stewart's Diss. p. 75.

life. The work by which he is best known, and which gave occasion to much controversy among metaphysicians, is entitled the "*Search after Truth*;" a work which combines great abstraction of thought with a lively fancy and glowing eloquence, and affords "ample illustrations both of the strength and weakness of the human understanding." The distinctive feature of his metaphysical system is, that the Deity is the *efficient* and *immediate cause* of every effect in the universe, or, to adopt his own language, "*that we perceive all things in God.*"

Of his great antagonist, ANTHONY ARNAULD, it is only requisite to state here, that he combated most powerfully and successfully the metaphysical errors of Malebranche, in an elaborate work on "True and False Ideas;" in which principles are maintained similar to those advocated by Locke, in his celebrated "Essay on the Understanding;" and also that he was the author of a valuable work on dialectics, entitled "The Art of Thinking," since known by the name of the *Port Royal Logic*.

389. It is gratifying to the friends of revealed truth to perceive, that there has never been a period in which genius, and talents, and learning, have not been employed in its defence, far superior to the proudest attainments of its mightiest adversaries. This remark will eminently apply to the brilliant intellectual æra, which is now passing under review; the æra of *Pascal*, and *Barrow*, and *Cudworth*; of *Leibnitz*, and *Locke*, and *Newton*. Though the first of these did not professedly write on metaphysical subjects, yet his celebrated "*Thoughts*

on Religion," are full of profound reflections and sublime reasonings on topics of a highly intellectual character. The philosophical works of *Barrow,* no less than his polemical writings, reflect the highest credit on the genius of their author, and sufficiently justify the eulogium pronounced on his memory, "that he was second alone to Newton; and whether treating of philosophical, moral, or theological subjects, he seems always to bring to them a mind which feels itself superior to the occasion, and which, in contending with the greatest difficulties, "puts forth but half its strength."* *Cudworth* was the author of two erudite works, entitled "The Intellectual System," and "Immutable Morality," both of which were intended and well calculated to check the sceptical spirit of the age in which they were written. In the former of these learned and laborious performances, the speculations of the infidel philosophers of his day are distinctly traced to the atheistical sects of antiquity, of which a full and elaborate account is given. In the latter, a powerful and most convincing argument is maintained on the immutability of virtue, and its eternal obligation, in opposition to the systems which then prevailed, by which virtue and vice were confounded, the principles of morality subverted, and all moral distinctions annihilated. SAMUEL CLARKE flourished at a somewhat later period, and is chiefly to be regarded, in metaphysics, as the opponent of

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* Stewart's Diss. ut sup. p. 69.

Leibnitz, on the question of Liberty and Necessity; but he may not improperly be mentioned in this place, as one of the acutest metaphysicians of his age, and a powerful combatant of the sceptical philosophy; especially in his admirable discourses on " the Being and Attributes of God," and on " the Unchangeable Obligations of Natural Religion." To the preceding distinguished names might be added, those of Archbishops Bramhall and Tenison, Wilkins and Cumberland, and Henry More, with many others, who took a part in the *metaphysico-theological* controversies of that intellectual age.

Section X.

SKETCH OF THE LITERARY HISTORY OF LEIBNITZ.

390. Among the many scientific and intellectual philosophers, who flourished during the latter portion of the seventeenth century, Leibnitz occupies no subordinate place. It is somewhat difficult to determine among whom he should be classed, as his researches were directed to almost every department of physical and moral science, and his numerous writings include almost every subject of human investigation.

This great philosopher was born at Leipsic, on the 23d of June, 1646. In early youth, though insatiable in the pursuit of knowledge, he discovered no very marked preference to any one department of literature. His reading was most extensive; so excellent was his memory, that whatever he read became his own; and, consequently, his accumulation of knowledge was rapid and great. But when he had attained his fifteenth year, he manifested a decided partiality to mathematical studies, and wrote several theses on subjects connected with the abstract sciences, which acquired him great celebrity in the university of Leipsic. About the same time, he renounced the Aristotelian, in favour of the Cartesian philosophy, the latter of which systems had as yet made little progress in Germany. In 1666, he published his first treatise, the object of which was to shew how universal arithmetic might be applied to other sciences; and in the same year, his "Mathematical Demonstration of the Existence of God," made its first appearance, which was most certainly no ordinary achievement for a youth who had just attained his twentieth year.

391. Having then in prospect the legal profession, the attention of Leibnitz was naturally directed to the study of law. Several of his next publications related to jurisprudence; one of which introduced him to the friendship and patronage of the Elector of Mentz, by whom he was employed, for a short time, as private secretary. But nothing could divert his attention from the mathematics and philosophy. His flattering secular prospects were gladly renounced, and the determination fixed to devote his life to literary studies. The first of his tracts on natural philosophy, entitled "A Theory of Concrete Motion," was presented to the Royal Society of London; and his second, on the "Theory of Abstract Motion," to the Academy of Sciences,

at Paris; of both which philosophical institutions he had the honour to be elected a member. These were successively followed by numerous papers on mathematical and physical subjects, most of which have been preserved in a literary journal, published at Leipsic, under the title of "Acta Eruditorum." (§ 262.) At the same time, this indefatigable and almost universal genius was employed in preparing, at the request of the Duke of Lunenburg, a "History of the House of Brunswick;" several works on "The Law of Nations;" and some metaphysical tracts on "Knowledge, Truth, Ideas, Nature," &c. &c.

392. Passing over that remarkable fact connected with the literary history of Leibnitz, which relates to the invention of the *differential* calculus, (the particulars of which have been already detailed, § 264—266,) we shall advance to that period of his life, in which he was chiefly occupied with metaphysical speculations and theological controversies.

In 1695, he published, in a Parisian journal, a specimen of a *new system* of physics, in which he first intimated those peculiar doctrines relative to the connexion between the body and mind, which were afterwards more fully developed, and characterize his metaphysical system. This was followed by a treatise, entitled "Thoughts on Locke's Essay on the Human Understanding," then recently published. In this tract Leibnitz first appears as the antagonist of our great philosopher, and combats especially those parts of his celebrated work, which relate to *innate ideas*. The next production of his pen on metaphysical subjects, was a defence of his favourite doctrine of the *pre-established harmony*, in reply to the animadversions which Bayle and others had made upon it in literary journals. About the same period, his active mind was also employed in polemic theology; as is evident from two controversial tracts,—one, "A Logical Defence of the Holy Trinity," written against the Socinians; and the other, "on Human Liberty and Predestination," against the Remonstrants.

393. But his principal work, the production of his later years, and that in which his philosophical opinions were more fully developed, remains to be noticed. This was entitled, "Theodicea, or a Dissertation on the Goodness of God, the Liberty of Man, and the Origin of Good and Evil." This celebrated treatise was first printed in 1710, and made a great stir amongst the metaphysicians of that day. It evinced an immense store of erudition, a mind well disciplined to abstract logical reasoning, a lively imagination, and a highly cultivated taste; but at the same time, it discovered a love of novelty and fondness for speculation unworthy of a sound philosopher, and wholly at variance with the principles of inductive reasoning. By these metaphysical and polemic writings, he became involved in wearisome controversies with some of the most enlightened intellectual philosophers of that brilliant age; among whom were Locke and Newton, Clarke and Bayle,
ith many others of inferior name. The details of
e intellectual combats, on subjects the most ab-
e and difficult that perhaps have ever occupied

the human understanding, will be chiefly found in the volume of his works which contains his correspondence with learned men; and which, while they excite our admiration of the powers of genius exerted in their discussion, convince us that there are topics, about which the busy and inquisitive mind of man may sometimes be employed, in the investigation of which the mightiest intellects are but as little children. This indefatigable writer exhausted his latest energies in these abstruse speculations, and expired on the 14th November, 1716, in the seventieth year of his age.

SECTION XI.

SUMMARY VIEW OF THE PHILOSOPHY OF LEIBNITZ.

394. LEIBNITZ did not compose any systematic treatise on philosophy; but his opinions may be gathered from his numerous writings, composed at different periods of life. The volume, in which his metaphysical system is most distinctly stated, is his "Theodicea," to which a reference was made in the last section; from which, therefore, the following summary will be chiefly taken. It is of the more importance that the distinguishing features of the philosophy of Leibnitz be attentively marked, because of the influence it excited long after the death of its illustrious founder. While the metaphysics of Locke may be considered as laying the foundation of a new school of intellectual philosophy

in Britain, which has subsequently spread over a great part of the world, those of Leibnitz must also be acknowledged to have influenced, in no inconsiderable degree, the speculations and researches of most of the intellectual philosophers—Kant himself not excepted. To the opinions and writings of Leibnitz, in the judgment of Professor Stewart, is chiefly to be attributed the contrast between the continental philosophy, and the contemporary systems, which have sprung up in our own island.

395. On the nature of ideas, and the manner in which they are produced, there is no material difference between Leibnitz and his illustrious predecessor, Des Cartes, who had himself derived his notions on this subject from the Platonic school. (§ 191.)—Nor is it easy to mark a difference between the opinions of both Des Cartes and Leibnitz, and those of Locke, except in words: for Leibnitz, when writing on the origin of ideas, asserts, "that there is nothing in the understanding which has not been present to the senses, *but the understanding itself;* and Locke, in nearly similar terms, writes thus: —"External objects furnish the mind with ideas of sensible qualities; and the mind furnishes the understanding with ideas of its own operations." This cannot therefore be considered as forming a distinctive feature of the philosophy of Leibnitz; and those which are properly such, may be classed under four heads—his theory respecting *Monads;* his doctrine of the *Pre-established Harmony;* his scheme of *Optimism;* and his application of the "*Law of*

Continuity" to the phænomena of mind as well as of matter.

I MONADS.

396. Having imbibed the Cartesian notion of a *plenum*, and conceiving that the entire universe is filled with indivisible and uncompounded particles, he was led thereby to the fanciful hypothesis, that all space is replenished with a kind of substances called *monads*; by which he seems to have meant elementary active principles of nature, each of which is necessarily distinct from and independent of every other in the universe; but all of which derived their existence from God, the Great Supreme; and only self-existent *monad*. After all that Leibnitz has written on the subject of these mysterious substances, and all the explanations of his theory attempted by subsequent commentators, it is scarcely possible to attach any definite idea to the term, if any thing is intended by it, but the *ultimate particles*, of which the material universe is composed; in which case, it will appear to be but a modification of the ancient *atomic* philosophy. Yet it should seem, that this theoretical philosopher conceived of these monads as something different both from matter and spirit. They are not material, because he denied to them the properties of extension, durability, inertness, and other essential properties of matter. They are not spiritual, because he neither considered them as animated or rational. So attached was Leibnitz to this favourite hypothesis, that it seems to have pervaded his whole

metaphysical system; and in some instances he appears to have been betrayed by it into a boldness of speculation approaching to profanity; as when he asserts "that the Eternal Geometrician" (meaning thereby the Omnipotent Creator) is constantly employed in solving this problem: "The state of a single monad being given, to determine its past, present, and future state throughout th[illegible]iverse."

2. PRE-ESTABLISHED HARMONY.

397. Before the time of Des Cartes and Leibnitz, the opinion had generally obtained, that the mind and body acted *really* and *physically* on each other, though the mode of their reciprocal action was confessedly unknown. Des Cartes had maintained, that their nature and properties were so dissimilar, so contrary to each other, that this was utterly impossible, and therefore referred all mental action immediately to the influence and agency of God. Leibnitz carried this idea still farther, and contended that the human mind and body were two *independent*, but correspondent agents; which, like two machines, were so nicely adjusted to each other, as to appear to act in concert; as if two clocks were so constructed by a skilful artificer, as that, though wholly unconnected with each other, one should *point to* the true time, and the other *strike* the successive hours. This singular doctrine is thus stated by Leibnitz himself in his "*Theodicea.*"—"I cannot help coming into this notion, that God created the soul in such a manner, at first, that it should represent within itself all the simultaneous changes

in the body; and has so made the body that it must of itself do what the soul wills;" and in another place, "Every thing goes on in the soul, as if it had no body; and every thing proceeds in the body as if it had no soul." Hence he was led to speak of the soul of man as a *spiritual automaton*, in distinction from the disciples of Hobbes, Gassendi, and Spinoza, who represented it as *material;* a machine, however, so regulated by necessary, pre-ordained, and immutable laws, that no operation of the mind, nor any event in the universe, could possibly have been different from what it is. In a word, this great philosopher conceived, both of the corporeal and intellectual parts of man, as alike impelled by necessary causes, as exquisite pieces of mechanism constructed by the Divine Artificer, wound up and put in motion by the same power, and proceeding harmoniously in the performance of their several functions, though without any dependance on each other, or any reciprocal influence whatever.

3. OPTIMISM.

398. From the hypothesis briefly stated in the last paragraph, viewed in connexion with a firm belief in the being and attributes of God, a third distinguishing principle of the philosophy of Leibnitz obviously arose, viz. his scheme of optimism; which, in several respects, differs materially from that which had been previously obtained. Since, according to the doctrine of the *pre-established harmony*, all events in the physical and moral world resulted from the action of necessary causes,

operating mechanically, if the Being, by whom this wondrous mechanism was constructed and prearranged, be infinitely wise and good; it followed that "whatever is, is *best*." The particular modification of *optimism*, for which Leibnitz contends, may be clearly gathered from the allegory with which he concludes one of the books of his "*Theodicea*," in which "he represents Tarquin as complaining of his lot, first to Apollo, then to Jupiter; and is at length satisfied with his fate, by being introduced into the palace of the Destinies, and shewn that of all possible volitions, with their train of necessary consequences, that which led to his crime and fall, was, upon the whole, *the best*." It is easy to perceive, that this scheme involves the notion of *fatalism* in its grossest and most offensive form, that it is entirely subversive of moral agency and responsibility, and that it obliterates all distinctions between virtue and vice. How far this alarming result may have been counteracted or modified by the religious feelings and principles of the illustrious advocate of this scheme, we pretend not to determine; but assuredly "nothing could tend more directly, by a short and demonstrative process, to the utter annihilation of all moral distinctions."

IV. LAW OF CONTINUITY.

399. Another distinguishing feature of the philosophy of Leibnitz, to which he was led by his propensity to "*à priori*" reasonings, and the habit of generalization on all philosophical subjects, consists

in his universal application of the "*law of continuity*." This term has long since been familiar to natural philosophers, and has been generally admitted with reference to physical science. It is used to express that unbroken order, which pervades the system of the universe; so that no change takes place suddenly, but all is accomplished by *infinitely small* degrees. It has been shewn, for example, in the science of dynamics, that bodies do not pass *instantly* from one direction into another, but describe a greater or less curve in their transition from place to place. But whatever may be the conclusions to which scientific and experimental philosophers have been led by their minute observation of natural phænomena, it may be questioned whether the principle will admit of the universal application for which Leibnitz and his followers have strenuously contended. By him it was asserted that this is an eternal and immutable law of nature, applicable no less to the phænomena of mind, than to those of matter. In numerous passages of his writings, Leibnitz refers to this as an indisputable principle in metaphysical science. On this ground he maintains that there cannot be in an intelligent being an entire, and least of all, a sudden cessation of thought;—that there can be no such thing as death, but merely a succession of changes of condition; — and that there is a perfect gradation throughout the universe: so that the innumerable classes and orders of beings form an unbroken line, a continuous scale of existences, descending from the Deity to the lowest species of unorganized matter.

Applying the same principle to the history of human improvement, and the progress of science, it is maintained, that the human mind has advanced, and is still advancing—not *per saltum*—but, to adopt the language of mathematicians, by innumerable *infinitesimal* steps, towards perfection in knowledge, till it attain the highest elevation of which created intelligence is capable. The great metaphysical argument by which this theory is sustained, is, "that it is in the nature of things impossible that any body or substance, whether corporeal or spiritual, should be at the same indivisible instant in two different states—that of motion and that of rest." It falls not within the plan of the present work to discuss these philosophical opinions, but merely to record them as curious speculations, which may be distinctly traced to Leibnitz as their author, and characterizing his philosophical system.*

SECTION XII.

SKETCH OF THE LITERARY HISTORY OF LOCKE.

400. THE present retrospect of intellectual science will close with a brief notice of the life and writings of an individual who towers far above all his prede-

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* For a more detailed account of these several hypotheses, the reader is referred, with much pleasure, to the second part of the admirable Dissertation of Dugald Stewart, and the notes appended to that dissertation, in which the principal arguments for and against these metaphysical theories are stated, with

cessors and contemporaries in this department of literature, and who was the means of effecting a mighty revolution in the opinions of mankind on moral and metaphysical subjects, the effects of which are still apparent, and will probably continue to be felt through all succeeding ages. This truly philosophical writer may justly be considered as the founder of a new and more enlightened school of intellectual philosophy, which, having originated in Britain, has gradually diffused itself over the greater part of the civilized world. Considering the period in which he wrote, and the slender advances then made in moral science, he must be acknowledged to have achieved a work of no ordinary magnitude, and most deservedly ranks highest among the logical, metaphysical, and political reformers of mankind. It is obvious that both the nature and limits of the present work do not admit of an extended review of his intellectual system, and still less can it be expected to comprehend a discussion of its comparative merits. All that will be attempted in these concluding pages, is to present an outline of his literary history, and to glance at some of the more prominent features of his philosophy.

401. John Locke was born at Wrington, in Somersetshire, A.D. 1632. He was educated at Westminster School, and entered of Christ Church College, Oxford, in 1651. While yet an undergraduate, he acquired great distinction by his

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a precision and beauty, to which perhaps it would be difficult to find a parallel in our language. P. 37—59.

progress in polite literature. His collegiate education having been completed, he devoted himself to the study of medicine, intending to practise as a physician; and his distinguished attainments in that science, at an early period of life, may be inferred, from the honourable mention made of him by Sydenham, in one of his medical treatises, published A. D. 1676. To his skill in medicine, Locke was indebted for his introduction to the friendship and patronage of the Earl of Shaftesbury, and many other persons of talent and distinction. By his perusal of the writings of Lord Bacon and Des Cartes, he was led to renounce the logic of Aristotle, which still continued to be taught in the English universities, and adopt the more rational method of philosophizing suggested by the author of the Novum Organum. It was about this period, that the first rude sketch was framed of his celebrated Essay on the Human Understanding, the occasion of which has been related by himself with circumstantial fidelity, in the Prefatory Epistle to that far-famed work.* The design appears to have been formed of writing an analytical treatise on the philosophy of mind, and some materials were prepared for that purpose as early as 1670; but the political troubles in which he was involved, in common with his illustrious patron, the Earl of Shaftesbury, diverted him from his purpose, or rather induced him to suspend its execution, till a more auspicious æra should arrive.

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* "Five or six friends, meeting at my chamber, and discoursing on a subject very remote from this, found themselves quickly at a stand, by the difficulties that rose on every side. After we had awhile puzzled ourselves, without coming any nearer a resolution of those doubts which perplexed us, it came into my thoughts that we took a wrong course, and that, before we set ourselves upon inquiries of that nature, it was necessary to examine our own abilities, and see what objects our understandings were and were not fitted to deal with. This I proposed to the company, who all readily assented, and thereupon it was agreed that this should be our first inquiry. Some

402. The persecutions of the Nonconformists in England, and of the Protestants on the continent, led this enlightened author to direct his attention to the important subject of Religious Toleration. His admirable treatise on this subject was first published in 1689, and contains principles the most just and liberal on a subject then little understood by any denomination of the Christian world, most of whom were ready in their turn to justify as well as practise religious persecution. This important tract, which obtained for its author the highest reputation abroad, though at its first appearance it was little regarded at home, was followed by several others on political subjects, among which may be mentioned two "on Government," first

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hasty and undigested thoughts on a subject I had never before considered, which I set down against our first meeting, gave the first entrance into this discourse, which, having been thus begun by chance, was continued by intreaty, written by incoherent parcels, and after long intervals of neglect, resumed again as my humour or occasions permitted, and at last in a retirement, where an attendance on my health gave leisure, it was brought into that order thou now seest it." p. vii. fol. edit.

published in 1690, and several "on Currency," and other questions connected with political economy. His valuable work on Education next appeared in 1693, which was quickly followed by a treatise on "the Reasonableness of Christianity," which involved him in a controversy with the deistical writers of his age. To their opposition we are indebted for a judicious vindication of his former treatise, and some other polemic writings.

403. It is not, however, on any of these productions, excellent as they are in their kind, that the reputation of Locke, as an intellectual philosopher, principally rests; nor does he appear, in any of them, to have exerted the utmost force of his genius. While resident on the continent, during the exile of the Earl of Shaftesbury, to whose fortunes he had attached himself on a principle of gratitude, Locke first published, in a literary journal, of which the celebrated Le Clerc was editor, an abridgment of his "Essay on the Understanding," probably with the express design of calling the attention of mental philosophers to speculations then novel and untried, and, in many respects, at variance with generally received opinions. The leisure which he enjoyed at this period of voluntary exile from his native country, enabled him to prosecute, with greater vigour and success, the important work which he had so long meditated, and which was put to the press soon after his return to England, at the memorable æra of the Revolution. After having employed at least nine years in digesting and revising it, this truly

philosophical Essay (of which a brief abstract will be given in the next section), was first published A.D. 1690, in one folio volume; and it will be admitted, even by those who do not fully subscribe to his metaphysical creed, that the date of its publication constitutes an important æra in the history of intellectual science. During the latter years of his life, this great philosopher was employed in writing several works on subjects of public interest. Though labouring under great infirmity of constitution, he drew up, at the special request of William III., "a Scheme for the Comprehension of Protestant Dissenters within the National Church," an object which that enlightened monarch had much at heart. Several parts were added to his tract "on Toleration." Defences of his "Essay" were prepared, in reply to the animadversions of the Bishop of Worcester, Malebranche, Leibnitz, and others. To the above numerous list of his valuable writings, may be added his excellent tract on the "Conduct of the Understanding;" "Memoirs of the Earl of Shaftesbury;" and "a Paraphrase and Notes on the Epistles of Paul." Some of these did not appear till after his death, which took place at Oates, within the hospitable mansion of Sir Francis Masham, on the 28th of October, 1704, in the seventy-third year of his age.

SECTION XIII.

SUMMARY VIEW OF THE METAPHYSICAL SYSTEM OF LOCKE.

404. THE "Essay on the Human Understanding" is too well known to render it necessary that an extended analysis of its important contents should be introduced into this elementary volume. It may be presumed, that most, if not all, who shall honour these pages with an attentive perusal, are familiar with the principal topics of which it treats, and are in the constant habit of referring to it, as a *standard authority.* All that is necessary for our present purpose, is to present a very brief outline of the subjects discussed in this admirable treatise, as the shortest and most practicable means of exhibiting a summary view of the metaphysical system of its author.

In the first book, the question is discussed, whether there exist in the human understanding any *innate* notions or principles, whether speculative or practical. The negative of that position is maintained and defended by a great variety of conclusive arguments, drawn from universal observation and experience, carefully guarding against hypotheses and *à priori* reasonings. In the second book, the author proceeds more directly to his proposed object—that of analyzing the phænomena and operations of mind; and he does this, by explaining the nature, and inquiring into the origin of ideas;

all of which are distinctly traced to two grand sources, *sensation* and *reflection:* ideas in general are then classified under the heads of *simple* and *complex;* the *simple* including those derived immediately from the senses, as colour, solidity, &c., or obtained by reflection, as our ideas of pleasure and pain, existence or being, unity, power, &c.; the *complex* are subdivided into *modes, substances,* and *relations.* Among the former of these are enumerated as *simple modes,* those of space, duration, infinity, number, with others that proceed more directly from sensation, such as sounds, tastes, colours, &c. Among the *mixed modes* are comprehended most of the combinations of simple ideas, of which the mind is conscious, and of which language is, for the most part, composed. Under the next division of *complex* ideas—*substances*—are introduced many important and valuable distinctions, relative to the nature and properties of body and spirit. Under the third class of complex ideas, viz. *relations,* are included disquisitions into the relations of cause and effect, identity and diversity, good and evil, with their several varieties and modifications. In the third book, which is rather dialectic than metaphysical, the author proceeds to investigate language in general, and considers *words* as signs of ideas, under which logical division of the subject are introduced many important remarks on *terms* and *propositions*—on the use and abuse—the imperfection and improvement of language. The last book, which is, morally considered, the most important, treats of knowledge and opinion, of truth and evidence, of the grounds of human judgment, and the principles of human belief; concluding with some valuable sections on the province of reason as distinguished from that of faith, and the numerous sources of prejudice, error, or mental delusion.

405. Such is the wide field of investigation on which this great philosopher enters, in his celebrated "Essay;" including in one or other of its parts almost every topic that comes within the range of moral and intellectual science. To judge correctly, however, of its transcendant merits, we must not view it as it may *now* appear to the metaphysical inquirer, who possesses all the additional light and information which subsequent investigations have afforded. We must conceive of the science of mind, as it *then* existed, and endeavour to place ourselves in the position of those, who had just escaped from the trammels of Aristotle, or who were bewildered amidst the speculations of Des Cartes and Leibnitz; for these were the great authorities who had then acquired an almost universal ascendancy, and to whose genius and talents a homage, almost amounting to idolatry, was rendered. We cannot wonder that, at first, the development of a new and more rational system should have attracted little attention; that many prejudices should have been armed against it; and that, when promulgated to the world, it should have encountered great opposition.

406. There were two prominent features of Locke's metaphysical system, which occasioned much controversy at the time, and respecting which the

opinions of metaphysical writers are still much divided; these relate to the *origin of ideas,* and the *powers of moral perception.* Respecting the former of these, it is to be remembered, that there existed at that time, and still continue to exist, two grand classes, or rather schools of mental philosophers, which, for the sake of distinction, may be termed the *Cartesians* and the *Gassendists.* The *Cartesians,* (with whom, in this particular, Locke must be associated,) while they admit that a great part of our knowledge is obtained by sensation, contend also that the mind acquires no inconsiderable portion of its knowledge by reflecting on itself, and by attentively observing its own faculties and operations. The *Gassendists* assert, that all our ideas are derived from the senses, and that the intellectual phænomena admit of no other explanation than that which is furnished by analogies drawn from the material world, of which indeed it forms a part. The infidel philosophers of the two last centuries have laid claim to Locke, as the founder of their metaphysical systems, and affect to consider themselves his disciples; but it were easy to prove, from numerous passages in his writings and correspondence, that the latter theory is diametrically opposed to this fundamental doctrine of his philosophical creed, and belongs rather to the school of Hobbes and Gassendi, than that of Locke.[*]

407. The second of the principles adverted to, as characterizing Locke's system, bears more on ethics than metaphysics. From not having been

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[*] Stewart's Second Diss. pp. 16, 26.

well understood, and perhaps, in some instances, too loosely stated, many took alarm, and imagined that it involved moral consequences of the most dangerous kind. The train of arguments employed by Locke to prove that there are no *innate principles,* either speculative or practical, led some to imagine that his system was at variance with Scripture, and destructive of all natural religion and moral obligation. On this ground it was vehemently attacked by Stillingfleet; Lord Shaftesbury appears too, from some passages in his "Characteristics," to have formed the same apprehension. Nor those alone, but the illustrious and excellent Sir Isaac Newton, seems at first to have entertained similar fears, though he subsequently retracted that opinion, and acknowledged his error with all the ingenuousness of a true philosopher and sincere Christian.* But whoever attentively reads the "Essay" in question, must, it is conceived, be fully convinced that the consequences attempted to be drawn from this part of his system do not legitimately follow, and least of all, that the excellent author himself intended thereby to shake the foundations of natural religion.

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408. The retrospect which has been taken of the progress of human knowledge, in the two

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* In proof of this statement, Dugald Stewart has preserved two curious and interesting letters between these two greatest philosophers of the age, which do equal honour to both parties. *Vide* Second Diss. pp. 31, 32.

great departments of physical and intellectual science, might naturally suggest to the mind a great variety of important reflections. The writer will not, however, prolong a work, already far too extended for an elementary treatise, by any lengthened train of observations; and the rather as as he is persuaded, that an attentive perusal of the preceding pages can scarcely fail to have produced a conviction of those great moral truths, which he is most anxious to impress on the minds of youth — a conviction founded not on human opinion merely, but on the evidence of facts: — that the causes which have operated, in all preceding ages, to perpetuate ignorance or to impede the progress of knowledge, were, either an undue deference to human authorities, or a disposition to speculate without evidence — that every solid and valuable attainment, and even the most stupendous discoveries, are to be attributed to the rigid adherence of those by whom they were made to the processes of *induction* and *experiment* — that, great as have been the attainments and discoveries of past ages, and mighty the powers of genius by which they were achieved, there is no reason to imagine that nothing further is to be expected; for whoever pursues the track of inquiry marked out in the present volume, and takes a survey of the history of science, subsequently to the period at which this review terminates, will perceive, that there are vast regions yet unexplored, and still greater developments to be anticipated, as the reward of diligent investigation in future ages;---and finally, that on account of the present limitation of our faculties, and the necessary imperfection of our knowledge, it becomes us to pursue our investigations into the hidden processes of Nature, and still more, into the profound mysteries of Revelation, with a humble and devout mind; earnestly imploring divine instruction; and joyfully anticipating the period, when "that which is perfect shall come, and that which is in part shall be done away."

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